

The Effect of the Cook County, Illinois Tax on Sugar-Sweetened Beverages on Sugar Consumption

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Abstract

Between 2015 and 2018, Sugar Sweetened Beverage (SSB) taxes were enacted in eight localities in the United States varying from one to two cents per ounce. In this paper, we examine whether SSB taxes achieve the goal purported by supporters: reducing sugar consumption. We use household scanner data to estimate the effect of SSB taxes on sugar purchases. We find that each additional cent per ounce tax decreases sugar purchases across grocery store products by TODO%, TODO% of which is explained by reduced purchases of sugar from beverages. We document stockpiling

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behavior and cross-border shopping as two mechanisms consumers employ to reduce their tax burdens.

1 Introduction

Obesity remains among the costliest health issues in the United States today. Finkelstein et al. (2009) find that obesity related health expenses cost the U.S. between \$101 billion to \$173 billion in 2008 in 2018 dollars. Cawley and Meyerhoefer (2012) estimate significantly larger aggregate expenses totaling \$246 billion using an IV approach. As a potential solution to reducing the high medical costs of obesity, government agencies have relatively recently suggested reducing added sugar consumption (Committee et al., 2015). Sugar sweetened beverages (SSBs) are the source of nearly 40% of the average American’s consumption of added sugar (Committee et al., 2015) and about 7% of caloric intake (Allcott, Lockwood, & Taubinsky, 2019), several policymakers have recommended imposing taxes on SSBs to drive down sugar consumption and health costs.

While excise taxes on soft drink taxes have existed for many years in the U.S. and other countries, SSB taxes of the magnitudes examined in this paper (one to two-cents-per-ounce) began as recently as 2015 in the U.S. in Berkeley, California. Since then, several localities have followed in passing SSB taxes including Albany, California; Boulder, Colorado; Cook County, Illinois (home of Chicago); Oakland, California; Philadelphia, Pennsylvania; San Francisco, California; and Seattle, Washington. Despite these policy changes, the impacts of SSB taxes on the policy-relevant metric of sugar consumption have not yet been widely examined in peer-reviewed literature.

In this paper, our primary outcome of interest is the effect of SSB taxes enacted in the U.S. between 2015 and 2018 on total grams of sugar purchased. We use a large representative panel dataset with detailed purchase data and exploit variation across time and space in a differences-in-differences specification to complete our analysis. We find that on average, a one-cent per ounce increase in an SSB tax reduces total sugar purchases by TODO%. Additionally, we find evidence that TODO.

Although most of the SSB taxes passed in the U.S. were passed by voter referenda rather than by local government officials, the policies have been highly controversial. Proponents

of these measures have argued that like taxes on tobacco products, taxes on SSBs could be effective in improving public health while raising revenues that could be used for health education. Opponents have argued that the tax is poorly targeted given that consumers can substitute towards other sugary goods instead of beverages or simply evade the tax by shopping outside the borders of the taxed locality. Additionally, opponents have contended that the taxes would be regressive since SSBs constitute a larger share of poorer consumers' budgets than they do for those with more resources. In this paper, we do not take a stance on welfare changes, but we do find TODO.

[I believe that one of our main contributions relative to previous papers is that we can look at the entire basket of consumption goods rather than just SSBs. We should forcefully make this point in the introduction. We construct a novel dataset by combining detailed scanner data on the entire basket of a household purchases with upc level nutrition information. This allows us to see the entire nutrition profile of a household and how this responds to the Tax.

I also think that we should take a stance on welfare in the introduction, in the very least we should talk about the change in the price index of those affected. We can also look separately at the price indices of poor v. rich households. In so doing our study with address both the opponent and proponent arguments in a more complete way than the prior literature (at least based on what I remember). Related question: do poor households reduce sugar consumption? If poor household demand for sugar is inelastic, then the incidence of the tax would fall strongly on these households.

Another point that I believe we should make in the intro is that Cook county provides a unique testing ground to test whether costly interventions lead to permanent behavior changes. We find that it does not. Not the main point of our paper, but I think this probably relates to some vein of behavior literature.]

The remainder of the paper is organized as follows. Section 2 provides a background of the policies enacted and related literature. Sections 4 and 3 introduce the methods and data used, respectively. Section 5 summarizes our results. Section 6 discusses those results, and

Section 7 concludes.

2 Background and Related Literature

[Personal View: This section should be considerably shorter. Some of this information could be incorporated into the introduction, most notably the observation that other sugary products are a substitute for SSBs. The extensive health lit review could be put into the appendix. There was a section about internalities in the 2019 version that I think should be added in again.]

In this section, we provide background on beverage taxes in the United States and summarize existing related literature.

2.1 Beverage Taxes in the United States

While dozens of cities have considered taxing beverages, the first city to pass an SSB tax was Berkeley, California in November 2014. Berkeley’s Measure D levied a one-cent-per-ounce excise tax on the distribution of beverages with added sugar. Alcohol, milk products, beverages for medical use, 100% fruit and vegetable juices, water, and artificially sweetened beverages are all exempt from the tax. The tax had been announced to begin January 1, 2015, but implementation was delayed until March of 2015 (Falbe et al., 2015).

Nearly two years after Berkeley, other cities began enacting similar SSB taxes including Philadelphia, PA, (2017); Oakland, CA, (2017); Albany, CA (2017); Boulder, CO, (2017); San Francisco, CA, (2018); Seattle, WA, (2018). Cook County, IL, which includes Chicago, became the first county to enact a county-wide SSB tax on August 2 of 2017. Two months later on December 1, the county became the first locality in the United States to end an SSB tax. One can observe a timeline of SSB tax events in Figure 1 below.

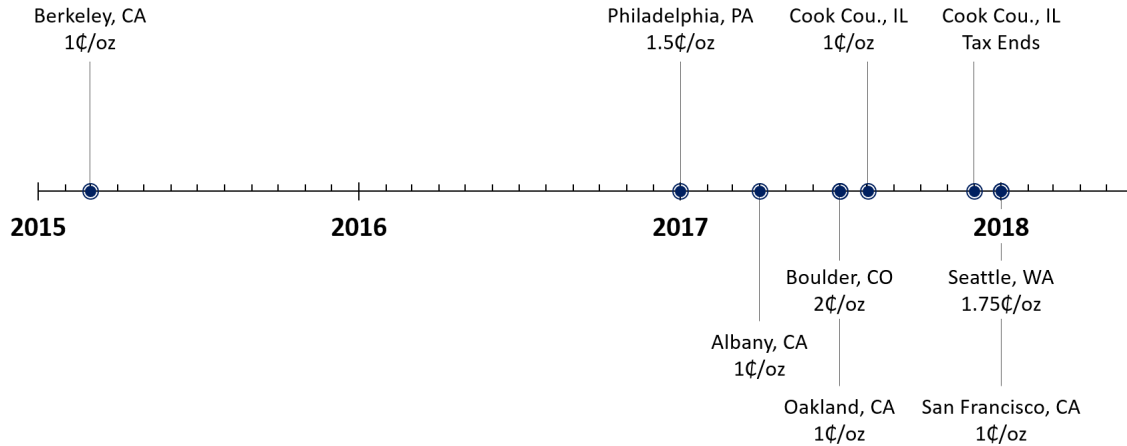


Figure 1: Rollout of SSB taxes in the United States

2.1.1 Berkeley, California

Each of the aforementioned studies find evidence that the tax in Berkeley resulted in high passthrough of the tax to consumers, which reduced SSB consumption. From these findings we learn that consumers are not perfectly elastic in their demand for SSBs, but we cannot say whether the taxes reduced sugar consumption because the authors did not examine demand interrelationships with other goods that contain sugar. About 39% of the average American's daily sugar consumption comes from beverages that are taxable under the examined policies (Committee et al., 2015). It would be a problem for policymakers if, for example, taxed consumers substituted away from soda towards chocolate milk or candy. These studies also suffer from only sampling consumers in one region and failing to track where consumers purchase SSBs, which may have changed following the tax.

2.1.2 Cook County, Illinois

As the lone county-enacted tax, lone repealed tax, and largest tax by geography and number of constituents affected, we provide some additional background on the Cook County SSB tax.

The Cook County Board of Commissioners passed the Cook County Sweetened Beverage

Tax Ordinance with a 9-8 vote on November 10, 2016. Initially, the one-cent-per-ounce tax was slated to go into effect on July 1, 2017; however, just four days earlier on June 27, the Illinois Retail Merchants Association filed suit, questioning the constitutionality of the tax. A state judge issued a temporary restraining order on the new tax until the case could be reviewed. On July 28, the same judge dismissed the lawsuit, and shortly thereafter on August 2, 2017, the beverage tax went into effect. As Cook County is home to 5.2 million residents, this tax became the most widespread SSB tax in the United States.

The Cook County beverage tax is unique among the other beverage taxes in the U.S. Besides having impacted the largest U.S. population to date, the law required that the tax be “borne by the purchaser of the sweetened beverage,” (Cook Co. Board of Commissioners, 2016). In practice, this meant that although the tax was collected by distributors, the law required that the tax be added to the price faced by consumers, usually in the form of a line-item on the receipt. This element of the policy has important implications for pass through and salience. Several large chain retailers added to the price tags of beverages a disclaimer that the tax would be added at the register (see Appendix A8 for an example.) However, it is possible that many retailers added the tax at checkout without including the tax in the displayed price, which may have reduced salience of the tax and possibly the impact on consumption (Chetty, Looney, & Kroft, 2009).

Importantly, the Cook County beverage tax was not levied on products purchased using SNAP benefits since federal law prohibits taxation of these goods. All other localities in the US that have enacted SSB taxes levied them on distributors - NOT consumers directly - and did not require that the tax be added at the register. As we will discuss in the next subsection, authors have found evidence of less than 100% pass through in these localities. Additionally, because these taxes are levied on distributors, the passed-through portion of the taxes could be paid for using SNAP benefits. Hence, the level at which the beverage tax is levied is a policy lever that can be used to possibly address regressivity concerns or subsidize a local-government budget with money from federal transfer programs. Another

element to consider is that poor households most likely to receive SNAP benefits are also those most likely to face the nutrition informational barriers that drive internalities from SSB consumption (Allcott, Lockwood, & Taubinsky, 2019b). If so, then exempting SNAP benefits from the tax may actually hurt consumers.

To grasp the magnitude of the tax in Cook County, consider some popular beverages from our data. The most popular (in gross sales) carbonated beverage in our data for Cook County consumers is a 12-pack of 12-ounce cans that retails for \$3.57 on average. The Cook County beverage tax adds \$1.44, or 40%, to the price of this 12-pack on average. The next most popular carbonated beverage is self-serve fountain beverages of assorted sizes, which retail for \$1.69 on average. For 20 - 32 ounce fountain drinks, the tax would add approximately 12% - 19% to the price. The most popular two-liter carbonated beverage retails for \$1.42 on average, and the tax adds 48% to the price of this 67.6-ounce product. Considering taxed non-carbonated soft drinks, the most popular beverage is a 59-ounce lemonade product that retails for \$2.35 before the tax, or 25% more with the tax. Across all carbonated beverages purchased in our dataset, we estimate the average percent tax to be about 23.5%.¹

It is worth noting that Chicago, circumscribed within Cook County, has levied a 3% tax on non-fountain soft drinks (paid by consumer) as well as a 9% tax on wholesale fountain drink syrups (paid by distributor) since 1994. These taxes are in addition to an Illinois state sales tax of 6.25%, Cook County sales tax of 1.75%, Chicago sales tax of 1.25%, and a Regional Transit Authority (RTA) tax of 1%. The Cook County beverage tax studied in this paper is in addition to these aforementioned taxes. Note that the other taxes do not change during the period studied (2017).

Another difference between the Cook County tax and beverage taxes in other localities is the taxation of both regular and diet beverages. Besides Philadelphia, Pennsylvania, Cook County is the only other locality in the US to have included diet beverages in its beverage

¹We only include carbonated beverages in this calculation since our data code both taxed and untaxed non-carbonated soft drinks together. Fruit-flavored juices (<100% juice) tend to be cheaper per ounce than carbonated beverages, hence the percent tax is likely higher than the estimate reported here.

tax. Since diet beverages are close substitutes for regular beverages but contain no sugar, taxing them may be counterproductive if the goal is reduced sugar consumption. On the other hand, if maximizing revenue is the primary goal, then taxing diet beverages is likely a dominant policy strategy.

On October 11, 2017, the Cook County Board of Commissioners voted 15-2 to repeal the ordinance, becoming the first governing body in history to revoke a beverage tax. The one-cent-per-ounce tax expired on December 1, 2017.

2.1.3 Other localities

The Berkeley tax is the longest standing SSB tax in the U.S., and the most studied for its impact on consumption. Falbe et al. (2015) randomly surveyed retail establishments in San Francisco, Oakland, and Berkeley both before and after the tax change and found that the one-cent-per-ounce tax led to 0.46-0.67 cent increase in the price per ounce, depending on the type of beverage. In a follow-up study, Falbe et al. (2016) used a repeated cross-sectional survey of low-income and minority households before and after the tax. Participants were asked how often they consume different types of beverages each week or month, and total SSB consumption was inferred from their responses. The authors found that SSB consumption decreased by 21% in Berkeley while it increased by 4% in comparison cities. L. D. Silver et al. (2017) used store surveys and point-of-sale scanner data for three Berkeley and six non-Berkeley supermarkets to assess the tax pass through. They found that the tax pass-through was near 100% for large chain supermarkets and smaller for others. They also found that sales of SSBs decreased in Berkeley relative to other cities. Cawley and Frisvold (2017) add to the literature that stores in Berkeley pass through more of the tax to consumers the further away they are from borders with neighboring untaxed localities, *ceteris paribus*.

Each of the aforementioned studies find evidence that the tax in Berkeley resulted in high, but not 100%, pass-through of the tax to consumers, which reduced SSB consumption. From these findings we learn that consumers are not perfectly elastic in their demand for SSBs,

but we cannot say whether the taxes reduced sugar consumption because the authors did not examine demand interrelationships with other goods that contain sugar. While about 39% of the average American’s daily sugar consumption (Committee et al., 2015) and about 7% of daily calories (Allcott, Lockwood, & Taubinsky, 2019) come from beverages that are taxable under the examined policies, it would be a problem for policymakers if, for example, taxed consumers substituted away from soda towards chocolate milk or candy. Most of these studies also suffer from only sampling consumers in one region and failing to track where consumers purchase SSBs, which may have changed following the tax. Additionally, these studies rely on survey data, which likely contain significant response bias. Given the increased attention of the potential negative health effects of SSBs and respondents’ tendencies to provide prosocial answers to surveyors², it would not be surprising to find that respondents underreport their SSB consumption to a larger degree following implementation of the tax.

More recently, other authors have examined the SSB taxes in Boulder (Cawley, Frisvold, Jones, et al., 2020), Oakland (Cawley, Frisvold, Hill, et al., 2020b), and Philadelphia (Cawley, Frisvold, Hill, et al., 2020a). In Boulder, Cawley and coauthors find that nearly 80% of the two-cents-per-ounce tax in Boulder was passed on to the consumer. Importantly, they note that about one-fifth of the retailers surveyed added the SSB tax at the register rather than into the shelf-price, which may have reduced saliency of the tax, perhaps lowering its effectiveness (Chetty, Looney, & Kroft, 2009). In Oakland, TODO. In Philadelphia, the authors find that consumers purchased 8.9 ounces of SSBs per shopping trip less from stores within the city relative to consumers who purchased SSBs from stores outside the city. They also find evidence that city residents increased their purchases of SSBs outside the city.

One important variation between the taxes examined in this paper is whether or not

²Researchers have observed that people tend to overreport socially positive behaviors like voting (B. D. Silver, Anderson, & Abramson, 1986) and attending church (Hadaway, Marler, & Chaves, 1993) but underreport socially negative behaviors like declaring bankruptcy (Locander, Sudman, & Bradburn, 1976) and using illegal drugs (Mensch & Kandel, 1988). See Krumpal (2013) for a review of the literature on “Social Desirability Bias.”

sugar-free diet beverages are taxed, which is the case in the Cook County and Philadelphia SSB taxes. As such, we investigate heterogeneity in substitution along this difference. Future work that examines the impact of SSB taxes on weight loss will need to consider this difference as well. Finally, it is important to note that all of the policies enacted exempt alcohol, baby formula, beverages in which milk is the first ingredient, beverages used for medical purposes, and 100% fruit and vegetable juices. Several of these products contain nontrivial quantities of sugar or carry externalities that may outweigh the reductions in obesity-related social costs.

2.2 Effect of SSB taxes on health

An often reported goal of SSB tax supporters is to reduce consumption of sugar. While there may be other mechanisms through which decreasing consumption of SSBs improves health, such as encouraging substitution towards more nutrient-dense foods, reducing total caloric consumption, and reducing consumption of other potentially health-harming ingredients present in SSBs, we focus our attention on the mechanism of decreasing sugar consumption. In this section, we provide background on the evidence that decreasing sugar consumption improves health and the ways by which SSB taxes may or may not reduce sugar consumption.

2.2.1 Effect of sugar consumption on health

TODO direct link papers

Two randomized controlled trials have directly tested the effect of SSBs on obesity. Ebbeling et al. (2012) provided half of 224 overweight adolescents with a multicomponent intervention to reduce SSB consumption including home delivery of water and non-nutritive sweetened beverages (NNSBs) and regular phone calls and check-in visits. Control participants were provided \$50 supermarket gift cards twice over the year-long period. By the end of the intervention, treated participants reduced their consumption from over 1.7 SSBs per day to nearly zero whereas control participant SSB consumption remained greater than zero.

The authors find that treatment reduced endline BMI by two percentage points more than control participants' BMI loss. In another experiment, de Ruyter et al. (2012) provided 641 children with 8 ounce cans of sweetened beverages daily, half of which were SSBs and the other half NNSBs. Participants were not made aware of how their beverages were sweetened as the can labeling was made consistent across conditions. The authors estimate that participants assigned to the SSB condition gained 19 - 35% more bodyfat than did those assigned to the NNSB condition.

In both experiments, the authors examine the effect of SSBs versus experimenter-provided NNSBs on weight loss. This nudged substitution is unlike supermarket conditions where consumers face nonzero prices for noncaloric beverages, so it is not obvious that consumers would respond to SSB taxes by substituting towards sugar-free products. However, it is reasonable that consumers may substitute towards other sweet products. It is generally accepted in the scientific community that sweetness carries a signal of nutrient density, which through evolution has endowed animals with an innate preference for sweet foods. Furthermore, scientists have produced evidence that sweetness can be addicting in animals (see Avena, Rada, and Hoebel (2008) for a review). The addictive properties of sweetness are not unique to sugar. Lenoir et al. (2007) find that 94% of the rats employed in their study preferred saccharin-sweetened water over intravenous cocaine when provided both options and after having experienced both substances for several days.

If the findings from these animal models apply to humans, then one should *expect* humans to seek sweetness elsewhere if not in the form of SSBs. Indeed, medical researchers have identified evidence of “reward homeostasis,” which if imbalanced can cause seeking of food-derived pleasure even in the absence of hunger (see Bellisle et al. (2012) for a review). This theory predicts that food satiation is a function of both calories consumed and achieving an individual's expected level of sweet-tasting foods. In one test of this theory, Lemmens et al. (2009) found that fasted subjects who were provided chocolate mousse instead of an isocaloric cottage cheese of the same weight subjectively reported less hunger and less desire

for additional food.

The implication of this theory is that policies that make sugary foods more expensive while maintaining or even lowering the price of non-sugary, sweet foods (i.e. artificially sweetened foods) would help consumers achieve “reward homeostasis” and reduce calories sought whilst not hungry. Hence, SSB taxes may be more effective at reducing obesity if diet beverages, which provided sweetness but no calories, are available as lower cost substitute beverages. This idea has been tested experimentally by Peters et al. (2014) and Peters et al. (2016) who provided overweight, diet-beverage consumers vouchers for either diet beverages (treatment group) or water (control group) and asked them to consume at least 24 ounces of their assigned beverage per day for one year concurrent with enrollment in a weight loss program. At the end of the one year trial, the treatment group had lost 6.6% of initial bodyweight while the control group had lost 2.6%. Although the authors did not collect food diary data and thus cannot examine whether participants assigned to the water condition consumed more sugary goods, the experiment provides suggestive evidence that diet beverages may help consumers maintain reward homeostasis without consuming sugar. On the other hand, taxing diet beverages increases collected revenues, which may be an important element of the policymaker’s objective function.

2.2.2 How SSB taxes reduce sugar consumption

For SSB taxes to be effective reducing sugar consumption, several mechanisms must function simultaneously. First, the tax must decrease SSB consumption. If the tax pass-through rate is low, or if consumers are very inelastic in their demand for SSBs, then the tax may have little impact on SSB consumption. As mentioned in Section 2.1.3, existing research has validated that indeed, the pass-through rate is high and consumers do reduce their purchases of SSBs when prices increase. In this paper, we emphasize another potential mechanism through which consumers may not significantly reduce their SSB consumption: shopping at untaxed grocery stores. It is conceivable that consumers who shop regularly outside their localities

may be unaffected by SSB taxes, or even that consumers may begin shopping at different stores following the tax, as Cawley, Frisvold, Hill, et al. (2020a) found in Philadelphia. Our data are less likely to contain reporting bias given that subjects are incentivized to report all purchases whereas participants may under report their consumption of untaxed SSBs to a surveyor located in a taxed locality.

Even if the tax manages to reduce consumption of SSBs, consumers can offset the decrease in sugar consumed from beverages by consuming more sugar from other foods. Indeed, about 68% of US packaged foods and beverages (by caloric share) contain caloric sweeteners (Popkin & Hawkes, 2016), which may make it challenging for households substituting away from SSBs to select products that do not contain sugar.

3 Data

We identify the effects of SSB taxes by linking several data sources. First, we observe household-level food purchase and demographic data from the Nielsen Homescan Survey, a nationally representative panel of 40-60,000 households from 2004 to 2016. These data have been used to assess the effects of other taxes. Harding, Leibtag, and Lovenheim (2012) use the homescan data to assess the impact of cigarette taxes, especially for panelists living close to state borders. Cotti, Nesson, and Tefft (2016) look at how tobacco taxes affect smoking cessation product purchases. Dharmasena and Capps Jr (2012) assess the effects of a hypothetical tax on sugar. Colchero et al. (2016) and Colchero et al. (2017) use Nielsen panel data in Mexico to evaluate the impact of a one-peso per liter tax on SSBs.

Nielsen provides recruited households with a handheld barcode scanner and asks them to record every item they purchase. By scanning their purchased products, households earn points that can be redeemed in a rewards catalog much like credit card reward programs. The households can earn higher value rewards the longer they remain in the panel, so households are additionally incentivized to participate in the panel for multiple years (the median

household participation duration is about 7 years). Nielsen collects household characteristics including zip code level geographic identifiers, household size, age of household members, race, income range, and more. In Table 1, we present descriptive statistics of households in the Chicago DMA sample by treatment status.

Participants are asked to scan the UPC codes of *all* the products they buy following shopping trips and provide information on the location of the purchase. If the purchase was completed at a Nielsen partner retail outlet, the price of the purchased item is automatically recorded as the average price of that product during the week that the customer recorded the purchase. If the purchase was made at a non-participating retail outlet, the participant is asked to manually input the price. If the product does not have a barcode as is the case with raw fruits and vegetables, households can record their purchase by scanning a barcode for the corresponding item printed in a provided booklet. Given that households may forget or choose to omit recording some of their purchases, the Nielsen Homescan Survey data likely contain measurement error. However, provided the measurement error is uncorrelated with introduction of SSB taxes, our findings, presented as percent changes, should remain unbiased. Levels of consumption presented in the data should be considered underestimates given the high likelihood of under-reporting by households (Einav, Leibtag, & Nevo, 2010).

We match the UPC codes from purchases in the Nielsen data with product-level nutrition data, thereby permitting us to observe total quantities of nutrients purchased by each household per month. Our nutrition data come from three sources. First, we use proprietary nutrition data from Syndigo, who provide UPC-level product information including the Nutrition Facts (amount of each micro and macronutrient listed), ingredients, product size, description, and brand for over 220,000 branded packages.³ We use an imputation procedure, described next, to match similar products that do not have a direct UPC match. Second, we use the US Department of Agriculture’s FoodData Central to gather nutrition information for as many of the remaining products as possible. Finally, for all remaining

³The data are licensed by over 2,000 consumer applications and have been used to estimate nutrients purchased by Nielsen panelists by other authors including Dubois, Griffith, and Nevo (2014).

products, we use the search features of major online retailers to find images of the Nutrition Facts panel and manually record the information.

To match nutrition data to the Nielsen product data, we follow a procedure similar to that of Dubois, Griffith, and Nevo (2014). We first drop non-food products, alcohol, tobacco, weight-loss/diet aids, and reference card goods.⁴ We then merge on UPC code, which matches about 52.8% of the purchased UPCs. Next, for products without a direct match, we match within product (string description of the product), brand, product module,⁵ size type (measured in counts versus milliliters versus grams), flavor, variety, type, formula, and style. This step adds 23.8% to the matched data. Next, we relax the brand requirement, which permits matching of store-brand goods and adds 11.2% of purchased products.⁶ Next we relax the flavor, variety, type, formula, and style requirements, which allow for another 7.6% of products to be matched. For 4.0% of products, we impute within product module for those product modules that have sufficient matched observations. For the remaining product modules, or 0.5% of purchased products mostly comprised of fresh produce, we manually look up and enter nutrition information.

To reduce the influence of outliers, we topcode our aggregated nutrient measures at the 99th percentile for all values greater than the 99th percentile.

4 Methods

In this section, we describe the empirical strategies used in this paper.

⁴Reference card goods are products without a barcode that panelists can report they purchased by scanning barcodes listed in a barcode reference booklet. These reference barcodes are associated with pictures and standardized item descriptions (such as “bakery item”). We drop these products since we cannot infer accurate nutrition information, and reference card goods are vastly underreported relative to products that have barcodes. Nielsen provides alternative panelist weights for analyses that include reference card goods.

⁵over 1,000 product categories defined by Nielsen

⁶The Syndigo data do not include store-brand goods.

4.1 Effect on food and nutrient purchases

We use a differences-in-differences specification to examine the impact of the beverage tax on food and nutrient purchases. We compare the change in monthly purchases during the taxed period by households living in Cook County, Illinois to that among counterfactual households. Our specification is as follows:

$$y_{it} = \beta_1 \tau_{s(i)t} + \gamma_i + \delta_t + \epsilon_{it} \quad (1)$$

where y_{it} is the total purchases of a food or nutrient y by household i during month t , γ_i and δ_t are household and time fixed effects, respectively, and ϵ_{it} is an unobserved model residual. $\tau_{s(i)t}$ is the beverage tax in a locality-month with units cents-per-ounce where $s(i)$ is the locality where household i resides. Under the parallel trends assumption, unconfoundedness, and SUTVA, the coefficient of interest, β_1 , is interpreted as the average causal effect of the tax on monthly purchases of y during the observed taxed period. In practice, we will take the inverse hyperbolic sine of y such that our results can be interpreted as percent changes.

Choosing a counterfactual that satisfies all of the assumptions listed above is challenging. In our preferred specification, we use households living in the Chicago Designated Market Area (DMA)⁷ outside of the Cook County border as the counterfactual. While it is reasonable that households in the same DMA likely experience similar region-specific shocks thereby increasing the plausibility of the parallel trends and unconfoundedness assumptions, SUTVA is potentially less believable. For example, it is conceivable that control households may shop at grocery stores inside Cook County, or stores outside the border offer promotions or increase marketing to attract additional business during the taxed period. As a robustness check, we additionally estimate our specifications using households who reside in the top ten

⁷Nielsen's DMAs are similar to the Census Bureau's Metropolitan Statistical Areas.

largest U.S. counties by population, other than Cook County, as well as the ten most similar counties to Cook County by population density. While it is less plausible that households in distant counties experience similar regional shocks, it is reasonable to expect that these households are insulated from spillovers caused by the Cook County beverage tax.

To examine heterogeneous treatment effects, we add an interaction term to Equation 1:

$$y_{it} = \beta_1 \tau_{s(i)t} + \beta_2 \mathbf{I}_i \tau_{s(i)t} + \gamma_i + \delta_t + \epsilon_{it} \quad (2)$$

where \mathbf{I}_i is a household-specific, time-invariant covariate of interest. Specifically, we add interaction terms with key demographic variables, such as household income, to identify if the tax may have had differential effects across these demographic variables. Household income is of particular interest, besides for examining the potential regressivity of the tax, since beverages purchased with SNAP benefits were exempted from the tax.⁸

We also estimate Equation 2 with \mathbf{I}_i as percentiles of pretax levels of regular soda purchases, scaled by the inverse of total monthly expenditures. In this specification, β_2 identifies the difference in treatment effects for high soda purchasing households to those that do not purchase soda. Low soda-purchasing households in Cook County can be thought of as an additional control group since they face less exposure to the tax yet experience the same county-specific shocks that high soda-consuming households experience.⁹

Finally, given the potential for Cook County residents to purchase beverages across the border, we estimate Equation 2 setting \mathbf{I}_i as indicators for the household’s “layer” within the county, thereby helping us understand whether the tax had larger effects for those further from the border. We code all households in our sample using their residential zip code to

⁸We cannot directly observe whether SNAP benefits were used to pay for products, but we can observe household income ranges as well as if an alternative to cash and credit was used. Unfortunately, fewer than 100 households in our treatment sample can be classified as SNAP-eligible households, and an even smaller subset of these use cash and credit alternatives. Hence, we focus our analysis examining heterogeneity along income ranges.

⁹Regular soda was not the only beverage taxed, so these households may have still experienced some exposure to the tax.

be one of five categories: outside border, cross border, on border, and two inside-border categories depending on linear distance to the nearest untaxed zip code. We depict these layers in Figure 3. In our analysis, we drop the 50 cross-border households given their small numbers and unclear taxed status.¹⁰ We omit an indicator for outside-border households, and hence all coefficients are interpreted as the average change in purchases during the tax for a given layer relative to outside-border households.

When estimating Equations 1 and 2, we cluster our standard errors at the zip code level to allow for arbitrary serial correlation within households in the same zip code over time. While the Cook County beverage tax was levied at the county level, we are unable to reliably cluster our errors at the county level since our sample is comprised of too few counties.

4.2 Effect on quality, intensive margin, and substitution

Since the SSB taxes are excised on a per-ounce basis rather than a percentage of value, the percent price increases of cheaper goods under the tax would be more than the percent price increases of more expensive goods, which may drive consumers to substitute towards higher cost SSBs (Harding, Leibtag, Lovenheim 2012). However, the negative income effect induced by the tax may cause greater consumption of relatively inferior SSBs. To examine changes in SSB quality, we will construct a quality measure by ranking products by average price (per ounce) across retailers. Note that if tax pass-through is consistent across products, then this ranking would not change after the tax is enacted since the per ounce prices would simply increase by the amount of the pass-through. We will estimate a specification similar to Equation 1 except that the outcome variable of interest is z_{ist} , the average quality score of the products purchased by household i in county s during month t .

Another consideration, following the literature referenced earlier that humans have an innate desire for sweetness, is that consumers may substitute towards SSBs with higher

¹⁰Including an indicator variable for this group in our specifications has little influence on the results, and we do not have ample precision to draw any conclusions from this group.

concentrations of sugar per-ounce.¹¹ This would be consistent with the observed behavior of smokers who smoke cigarettes more intensively (extract more nicotine per cigarette) when cigarette taxes are increased (Adda & Cornaglia, 2006). This substitution, if it exists, could help explain how SSB consumption could fall after tax implementation yet sugar purchases remain unchanged. To examine this margin, we calculate average grams of sugar per ounce of purchased beverages per month and use this as our outcome variable in Equation 1.

Finally, it is theoretically ambiguous whether consumers are more likely to consume more sugar from nonbeverages while the tax is in effect. On one hand, if sweetened beverages and nonbeverages are net substitutes, then some of the reduction in sugar from reduced consumption of SSBs should be offset by increased consumption of sweetened nonbeverages. On the other hand, imposing a tax as large as the one studied here may send a credible signal to consumers that sugar is unhealthy, which may cause consumers to update their preferences. If so, then consumers may substitute away from all sugary products including sugary nonbeverages. In this case, total sugar consumption would decrease by more than the amount that sugar from SSBs decrease. To answer this empirical question, we examine the impact of the tax on both total sugar and SSB sugar and compare the two estimates.

4.3 Welfare

While the above methods help us understand whether the tax may reduce sugar consumption and improve health, they do not capture the implicit costs to households in terms of an increase in their price index. A first pass way to calculate this cost is to note that prior to the implementation of the tax in Cook-County, around 2% of a household’s budget (in our scanner data) is spent on sugar sweetened beverages. If we combine that fact with the average 23.5% price increase from the tax (assuming 100% pass-through) and average Nielsen purchases of \$551 a quarter we get that the tax costs each household \$13.61 a month on average. However, this approach (similar to computing a Laspeyres price index) ignores

¹¹Consumers may employ other behaviors, such as reducing the amount of ice in one’s cup when purchasing soft drinks, that affect the intensive margin but are unobservable in our data.

the household's ability to substitute to cheaper products, as well as taste-changes that may occur as a result of the tax.

In order to examine the welfare costs of the tax, we develop a simple household model where households derive utility from grocery consumption and from their health. Some of the health effects of sugar are non-internalized, which induces the policy maker to impose a tax. The household's utility is given as:

$$U(C_t, H(S_t)) = \log(C_t) + \alpha H(S_t) \quad (3)$$

where $H(\cdot)$ is a function of sugar on the health of the consumer that is not internalized. C is a nested CES aggregation of N_m grocery goods within M different categories:

$$C_t = \left(\sum_m^M \left(\sum_k^N (\varphi_{k,t} c_{k,t})^{\frac{\sigma_m-1}{\sigma_m}} \right)^{\frac{\sigma_m}{\sigma_m-1}} \right)^{\frac{\sigma}{\sigma-1}}. \quad (4)$$

The household derives utility from consumption of each product at time t $c_{k,t}$. This per product utility varies with time specific taste shocks for each product $\varphi_{k,t}$. This taste parameter is meant to represent all of the internalized utility that the household derives from the product (including its health benefits). So if the sugar tax increases the household's knowledge about the negative health effects of sugar than we might expect φ to decrease for products with high amounts of sugar. Each product group has its own specific elasticity of substitution σ_m and there is another elasticity of substitution across product categories σ .

Following standard CES optimization, each product category m has price index at time t of:

$$P_{tm} = \left[\sum_k \left(\frac{p_{k,t}}{\varphi_{k,t}} \right)^{1-\sigma_m} \right]^{\frac{1}{1-\sigma_m}}. \quad (5)$$

What matters for the household's price index is the taste adjusted price of the good $\frac{p_k}{\varphi_k}$ rather than simply the price. This is important for our analysis as the tax increases the price of SSB, but can also affect the "taste" for sugar given that the tax may signal to consumers that sugar is a bad. It should be noted that both the taxes affect on increasing the price of SSB as well as decreasing the taste for sugar will both act to increase the consumer's price index. So the price index could increase even more than the simple case depending on the consumer's ability to substitute to other goods.

We use the reverse weighting method from Redding and Weinstein (2020) to calculate the elasticity of substitution for each product module σ_m and the elasticity of substitution across product modules σ using all of the data in our sample (both inside and outside Cook county). We also follow Redding and Weinstein (2020) and invert the price index in (5) so that we do not need to estimate the time specific good taste parameter $\varphi_{k,t}$. The change in the price index in a product category m between any two periods then becomes:

$$\log \frac{P_t}{P_{t-1}} = \frac{1}{\sigma_m - 1} \log \frac{\lambda_{t,t-1}}{\lambda_{t-1,t}} + \frac{1}{N_{t,t-1}} \sum_k \log \left(\frac{p_{kt}}{p_{k,t-1}} \right) + \frac{1}{\sigma_m - 1} \frac{1}{N_{t,t-1}} \sum_k \log \left(\frac{s_{kt}^*}{s_{k,t-1}^*} \right). \quad (6)$$

The first term $\frac{1}{\sigma_m - 1} \log \frac{\lambda_{t,t-1}}{\lambda_{t-1,t}}$ is the variety adjustment term first seen in Feenstra (1994) that accounts for increases in welfare due to new products ($\lambda_{t,t-1}$ is the budget share spent on products common to both periods). The number of products common to both periods is denoted by $N_{t,t-1}$ and the budget share of a product as a percentage of the total spent on common products is denoted by s^* . We estimate this price index change for every product

category (module described in data section) for households within and outside of Cook County. We then treat the category level P_m as prices and estimate (6) using category prices and shares to get aggregate price indexes for Cook county and outside of Cook county.

After determining the four price levels (Cook vs. counterfactual, pretax vs. posttax), we calculate the average compensating variation (in dollars) with:

$$CV = \bar{C} \left(\frac{P_{1,\text{Cook}}}{P_{0,\text{Cook}}} - \frac{P_{1,\text{counterfactual}}}{P_{0,\text{counterfactual}}} \right) \quad (7)$$

where \bar{C} is the average consumption (in dollars) among Cook residents in the pretax period. The intuition is as follows: suppose the price level increases by 10% in Cook County during the taxed period. Over the same time period, the price level increased in counterfactual counties by 6%. Hence, in the absence of treatment, (we assume) the price level in Cook County would have increased by only 4%, so the effective price increase caused by the tax is 4%. To “compensate” the consumer for the increased prices (and return her to her baseline level of consumption), we must provide her with 4% of the money she spent in the pretax period.

We use this compensating variation to estimate the dollar cost per-gram of reducing sugar consumption. Our measure will help policymakers conduct cost-benefit analyses of SSB taxes. These analyses must take into account 1) grams of sugar reduced per unit tax, 2) health cost savings per gram of sugar reduction, 3) compensating variation (social cost in terms of an increase in the price index), and 4) tax revenue. This paper provides estimates of 1) and 3). We leave it to other researchers to determine the health cost savings per gram of sugar consumed (2) and policymakers to determine 4).

5 Results

In this section we present results using the methodology discussed in Section 4 and data introduced in Section 3.

5.1 Effect on nutrients

Here we estimate the effect of the Cook County beverage tax on nutrients purchased, from all scanned food products, using Equation 1. To instill some confidence that our comparison group - Chicago DMA panelists who live outside Cook County - is a credible counterfactual, we plot the time series of average nutrients purchased per month by treatment group in Figure A1. We similarly examine panelist behaviors, such as number of trips, total expenditures, and items scanned per month across treatment arms in Figures A2. In both sets of time series plots, one can observe that pretreatment trends are remarkably similar with shocks occurring in both groups in the same months.

We present our estimates of Equation 1 for key Nutrition Facts nutrients in Table 2. We find that during the four months of the tax, Cook County households purchased 14.4 to 16.3 percent fewer grams of sugar than did control households during the same time period. We find significant decreases in carbohydrates purchased, but no significant decrease in non-sugar carbohydrates purchased. We find no change in fat or calories from sources other than sugar, and we find marginally significant decreases in calories, fiber, protein, and sodium, but these decreases become insignificant after adding sampling weights and balancing the panel. Interestingly, in the four months following removal of the tax, treatment households did *not* increase purchases of any nutrient relative to their pretax baseline. In particular, we can reject that households increased their sugar purchases in the four months following the tax to make up for the reduction in sugar purchased during the tax.

5.2 Effect on beverage purchases

The Cook County beverage tax targeted beverages that contain added caloric sweeteners, with some exceptions such as beverages whose first ingredient is milk, 100% fruit juices, and baby formula. We investigate how much the tax reduced purchases of some categories of beverages by estimating Equation 1 using the inverse hyperbolic sine of volume purchased of each beverage category as the outcome variable. Table 3 shows our findings. We find that regular soda volume decreased by 33.2 - 39.1%, diet soda volume decreased 14.3 - 27.0%, fruit drinks¹² by 30.5 - 35.5%, and liquid tea by 18.4 - 24.8%. Among these product categories that contain taxed products, we find no compensating increase among in the four months following the tax. However, the point estimates for regular soda are positive and one-sixth to one-third the magnitude of the decrease during the tax, suggesting that consumers may have partially offset the temporary reductions in regular soda purchased. Notably, we can reject that households maintained reduced levels of SSBs after the tax was removed.

Moving to product categories that contain mostly untaxed beverages, we find that bottled water demand increased 8.5% to 14.8%, but we cannot reject a 0% increase. We find weak evidence of increased demand for solid coffee but no change for liquid coffee.¹³ We find no change in demand for milk and no significant increase in alcohol purchases, but we cannot reject large increases.

In Table 4, we estimate effects of the tax on the intensive margin of purchasing select beverage categories. That is, we estimate Equation 1 setting the outcome variable to 1 if the household purchased any product in that category that month, 0 otherwise. We find that the tax decreased the probability of purchasing regular soda by 5.1 to 6.6 percentage points, diet soda by 2.0 to 3.8 percentage points, fruit drinks by 4.8 to 5.5 percentage points, and liquid tea by 3.4 to 4.1 percentage points. We find no significant change in the probability of purchasing beverages of other categories.

¹²100% fruit juice was not eligible for the tax, so some products in this category were not taxed.

¹³Liquid coffee products with added sweeteners were taxed, except those whose first ingredient is milk.

5.3 Effect on sugar from select sources

Here we characterize the change in sugar during the tax by the source of that sugar. We generate the results in Table 5 by fitting Equation 1 with levels of sugar from a given source as the outcome variable. During the tax, treatment households reduced their sugar purchases by 81 to 93 grams per month. We find that sugar reductions from regular soda can explain 61% to 81% of this total reduction, and fruit drinks can explain 17% to 25%. To see if households substituted towards sugary non-beverage products, we estimated the effects of the tax on grams of sugar from the "Candy" and "Cookies" product groups. We find directionally positive but not statistically significant changes in sugar from sweets, which we interpret as suggestive evidence that households may have substituted soda for other sweet foods, albeit not one-for-one in terms of grams of sugar.

After removal of the tax, we find that treatment households increased their purchases of sugar by 31 to 43 grams per month relative to their pretax baseline. Though this change is not statistically significant, it is between 33% and 47% of the taxed-period decrease. Interestingly, a large portion of this increase can be attributed to increases in sugar from fruit drinks. We do *not* find large increases in sugar from regular soda following removal of the tax.

5.4 Effect on shopping and scanning behaviors

Next we examine whether panelists changed their shopping or scanning behaviors during the tax. We again estimate Equation 1 using the inverse hyperbolic sine of each panelist behavior as the outcome variable of interest, and we show the results in Table 6. We find no evidence of changes in trips, total amount spent (as shown on the receipt), total amount spent on scanned items (as input by panelists), or number of scanned items with coupons or deals. We find marginally significant reductions in food expenditures scanned, number of items scanned, and number of food items scanned; however, these reductions become insignificant after including sampling weights. We find a marginally significant reduction in

number of storebrand items scanned, which remains significant after adding sampling weights and balancing the panel. In sum, we interpret these results as suggestive evidence that the tax did not reduce trips or amount spent at stores but may have shifted some spending from food to nonfood.

5.5 Treatment effect heterogeneity

In this section we look into heterogeneous treatment effects by household characteristics, geography, and pretreatment levels of soda purchases.

We begin by estimating Equation 2 using as outcomes the inverse hyperbolic sine of grams of sugar and ounces of regular soda purchased. For the interaction terms, we use dummies for household income range, race, and education.¹⁴ Relative to the baseline category of households with income under \$35 thousand, higher income households reduced their sugar less during the tax on average, though no difference is statistically significant. Compared to White households, Black and Asian households changed their sugar about the same amount, but households that identify as Other had much larger decreases, albeit not statistically significant. The differences by education are the smallest, showing little difference in treatment effects by education level.

Next, we examine the importance of distance from untaxed stores with respect to the effectiveness of the tax at reducing sugar consumption. Theoretically, households near the border face lower costs to avoid the tax than do households in the center of the taxed county since the cost to travel to an untaxed store is lower. We estimate Equation 2 after coding each household with an indicator variable for their zip-code layer as depicted in Figure 3. We present the coefficient estimates on the interaction term between the tax and the zip layer dummy in Table 8. While the coefficients are indistinguishable from zero for households who live in a border zip code, the coefficients are negative and significant for the two inner zip code layers.

¹⁴Race and education is that of the female head of household, or the male head of household if there is no female head.

To further examine whether cross-border shopping may explain the differences in treatment effects by geography, we estimate Equation 1 using the inverse hyperbolic sine of trips, expenditures, and grams of sugar separately for stores located on the same side of the Cook County border as one’s residence (“inside border”) and on the opposite side of the border (“cross border”). As can be seen in Table 9, we find that trips to inside-border stores decreased 2.2% to 4.5%, offset by a nearly equal increase in trips to cross-border stores. Expenditures decreased somewhat in inside-border stores while expenditures did not change in cross-border stores. Interestingly, sugar purchases decreased by 21% to 22% in inside-border stores while they *increased* 6.9% to 10.3% in cross-border stores. This observation highlights the importance of including products purchased at stores outside the taxed jurisdiction when estimating effects of county-level taxes. In our example, failing to account for cross-border purchases would overstate the effect of the tax on sugar purchased by more than 50%.

Finally, we examine effects of the beverage tax on sugar by pretreatment levels of soda purchases. We construct deciles by first calculating each households average monthly soda volume purchases during the year prior to the tax, excluding one month prior to the tax (to reduce bias from anticipatory effects). We divide this amount by monthly expenditures to so that the ranking does not simply capture the size of the household’s budget. Summary statistics for each decile can be found in Table A1. While deciles 1 and 2 purchase no soda before the tax, the top decile purchases about 730 ounces of regular soda per month and gets nearly 80% of its sugar from regular soda.

Ex ante, one would expect to find smaller treatment effects for low soda purchasing households relative to high soda purchasing households. Hence, estimating effects by soda decile serves as a placebo check, though it should be noted that low soda purchasing households could still have negative treatment effects since soda was not the only taxed beverage category. We present our heterogeneous treatment effect estimates by pretreatment soda decile in Table 10. We find no significant effects of the tax on sugar purchases for deciles 1 through 6, marginally significant negative effects for decile 7, and large, significant negative effects

for deciles 8 through 10. The coefficients for the top deciles indicate that the tax reduced sugar purchases by 29% to 44%. Additionally, we do not find compensating increases for any decile following removal of the tax. We interpret these findings as evidence that the tax reduced sugar purchases for high soda purchasing households while the tax was in effect but had no lasting impacts.

5.6 Consumer Price Indices and Welfare

As described in the welfare section, we estimate consumer price indices in the Chicago area for households that reside both within and outside Cook County. We find that Cook County had a relatively significant increase in the price indices of the soda product module and a minor increase in the overall retail price index during the period of the tax.

Figure 4 shows the change in the aggregate household budget share spent on soda before and after the tax. The budget shares in Cook county and the rest of Chicago track each other quite closer except in the months directly prior to the implementation of the tax, which is further evidence of stockpiling behavior. The similar trajectory of the share of soda products inside and outside cook county indicate that a simple Laspeyres index may not be a bad estimate for the actual change in the cost of living due to the SSB tax. The price of soda in Cook County on the other hand increases by around 1 cent per ounce, which indicates complete pass through.

Figure 5 shows our estimated results for the price index inside and outside Cook county. The top row shows the price index estimated for only soda products. The left hand side is the simple-Laspeyres index, while the right hand side is the CES Unified Price index (CUPI) where the aggregate household is allowed to have time varying taste shocks and CES utility. Both methods yield a 60 percent increase in the price index on soda for households in Cook County.

The bottom row of figure 5 shows the change in the overall retail price index in Cook county and outside, of which soda is only a small part. Once again the left hand side shows

the results from the Laspeyres price index, while the right hand side shows the full CUPI retail price index. The Laspeyres price index in Cook county is higher than outside Cook county for every month of the tax, with the exception of September. The Retail CUPI index paints a clearer picture: the price index of households with cook county increased by about 4 percent in August (the first month of the tax) and a further 1.25 percent in October before falling in December to 2 percent over July prices. This is compared to outside cook county that only had a 2.5 percent increase in retail prices during this period. Given that households in Cook county on average spent 285 dollars on Nielsen Retail purchases each month in 2017, the cumulative cost per-household of the four month tax was \$11.25 using the difference in Laspeyres price indices and \$24.21 using the difference in CUPI price indices. This is compared to an estimated XX drop in grams of sugar consumption during the same period.

6 Discussion

6.1 Limitations

Our approach has a few limitations. We observe sugar purchases, not sugar consumption, which is the policy-relevant metric. However, if we assume that the fraction of sugar purchased to sugar consumed does not change following the tax, our estimate of the effect of the tax on sugar purchases would additionally estimate the effect on sugar consumption. This assumption could be violated if, for example, consumers buy less sugar after the tax is enacted but consume the same amount by consuming a greater portion of their purchased sugar. It is not possible to test this assumption using the Nielsen data, though violations of this assumption likely bias our estimates *upwards* since consumers presumably start consuming a larger portion of the purchased sugar as it becomes relatively more expensive. Additionally, we cannot observe some intensive margin changes to soda consumption like consuming more soda from a container before disposal.

Additionally, we observe grocery store purchases that households scan, which does not include unscanned items such as food consumed away from home. Since SSB taxes studied in this paper are levied based on volume, SSBs sold at grocery stores are generally taxed at higher rates than are SSBs consumed at restaurants, which could result in substitution of SSB purchases away from home (TODO: cite existing literature on effect of taxes at restaurants). Finally, we do not examine health directly. While sugar consumption decreases during the taxed period, agents may simultaneously change other behaviors, such as exercise. Consider the agent who rationally reduces time spent exercising as her total caloric intake decreases. If large portions of the public behave in such a manner, the health care cost savings from reduced sugar consumption may be partially erased by other behavioral changes. Future research that examines the effect of SSB taxes on health expenditures directly is warranted.

7 Conclusion

In this paper, we use Nielsen household scanner data and UPC-level nutrition data to examine the effect of the Cook County, Illinois beverage tax of one cent per ounce on sugar consumption. Using a differences-in-differences specification, we find that during the taxed period, residents of Cook County reduced purchases of sugar by TODO%, TODO% of which can be explained by reduced sugar from beverages. We observe a substantial increase in purchases of taxed beverages in the month immediately before the tax is scheduled to go into effect. Taking into account these stockpiling behaviors we estimate that consumers reduce their sugar consumption by a more modest TODO% during the taxed period. Additionally, we document reduced effectiveness of the tax for residents who live near the border of an untaxed zip. Future work will provide an estimate of the cost in consumption dollars to reduce one gram of sugar consumed. Paired with knowledge of transfers and related costs as well as the health care cost savings of reducing consumption of sugar, policymakers can evaluate whether a beverage tax is well-suited for their constituents.

References

- Allcott, H., Lockwood, B. B., & Taubinsky, D. (2019). Should we tax sugar-sweetened beverages? an overview of theory and evidence. *Journal of Economic Perspectives*, 33(3), 202–27.
- Avena, N. M., Rada, P., & Hoebel, B. G. (2008). Evidence for sugar addiction: Behavioral and neurochemical effects of intermittent, excessive sugar intake. *Neuroscience & Biobehavioral Reviews*, 32(1), 20–39.
- Bellisle, F., Drewnowski, A., Anderson, G. H., Westerterp-Plantenga, M., & Martin, C. K. (2012). Sweetness, satiation, and satiety. *The Journal of nutrition*, 142(6), 1149S–1154S.
- Cawley, J., Frisvold, D., Hill, A., & Jones, D. (2020a). The impact of the philadelphia beverage tax on prices and product availability. *Journal of Policy Analysis and Management*, 39(3), 605–628.
- Cawley, J., Frisvold, D., Hill, A., & Jones, D. (2020b). Oakland’s sugar-sweetened beverage tax: Impacts on prices, purchases and consumption by adults and children. *Economics & Human Biology*, 37, 100865.
- Cawley, J., Frisvold, D., Jones, D., & Lensing, C. (2020). The pass-through of a tax on sugar-sweetened beverages in boulder, colorado. *American Journal of Agricultural Economics*.
- Cawley, J., & Frisvold, D. E. (2017). The pass-through of taxes on sugar-sweetened beverages to retail prices: The case of berkeley, california. *Journal of Policy Analysis and Management*, 36(2), 303–326.
- Cawley, J., & Meyerhoefer, C. (2012). The medical care costs of obesity: An instrumental variables approach. *Journal of health economics*, 31(1), 219–230.
- Chetty, R., Looney, A., & Kroft, K. (2009). Salience and taxation: Theory and evidence. *American economic review*, 99(4), 1145–77.

- Colchero, M. A., Popkin, B. M., Rivera, J. A., & Ng, S. W. (2016). Beverage purchases from stores in mexico under the excise tax on sugar sweetened beverages: Observational study. *bmj*, 352.
- Colchero, M. A., Rivera-Dommarco, J., Popkin, B. M., & Ng, S. W. (2017). In mexico, evidence of sustained consumer response two years after implementing a sugar-sweetened beverage tax. *Health Affairs*, 36(3), 564–571.
- Committee, D. G. A. et al. (2015). *Dietary guidelines for americans 2015-2020*. Government Printing Office.
- Cotti, C., Nesson, E., & Tefft, N. (2016). The effects of tobacco control policies on tobacco products, tar, and nicotine purchases among adults: Evidence from household panel data. *American Economic Journal: Economic Policy*, 8(4), 103–23.
- de Ruyter, J. C., Olthof, M. R., Seidell, J. C., & Katan, M. B. (2012). A trial of sugar-free or sugar-sweetened beverages and body weight in children. *New England Journal of Medicine*, 367(15), 1397–1406.
- Dharmasena, S., & Capps Jr, O. (2012). Intended and unintended consequences of a proposed national tax on sugar-sweetened beverages to combat the us obesity problem. *Health economics*, 21(6), 669–694.
- Dubois, P., Griffith, R., & Nevo, A. (2014). Do prices and attributes explain international differences in food purchases? *American Economic Review*, 104(3), 832–67.
- Ebbeling, C. B., Feldman, H. A., Chomitz, V. R., Antonelli, T. A., Gortmaker, S. L., Osganian, S. K., & Ludwig, D. S. (2012). A randomized trial of sugar-sweetened beverages and adolescent body weight. *N Engl J Med*, 367, 1407–1416.
- Einav, L., Leibtag, E., & Nevo, A. (2010). Recording discrepancies in nielsen homescan data: Are they present and do they matter? *QME*, 8(2), 207–239.
- Falbe, J., Rojas, N., Grummon, A. H., & Madsen, K. A. (2015). Higher retail prices of sugar-sweetened beverages 3 months after implementation of an excise tax in berkeley, california. *American journal of public health*, 105(11), 2194–2201.

- Falbe, J., Thompson, H. R., Becker, C. M., Rojas, N., McCulloch, C. E., & Madsen, K. A. (2016). Impact of the berkeley excise tax on sugar-sweetened beverage consumption. *American journal of public health*, 106(10), 1865–1871.
- Finkelstein, E. A., Trogdon, J. G., Cohen, J. W., & Dietz, W. (2009). Annual medical spending attributable to obesity: Payer-and service-specific estimates: Amid calls for health reform, real cost savings are more likely to be achieved through reducing obesity and related risk factors. *Health affairs*, 28(Suppl1), w822–w831.
- Hadaway, C. K., Marler, P. L., & Chaves, M. (1993). What the polls don’t show: A closer look at us church attendance. *American Sociological Review*, 741–752.
- Harding, M., Leibtag, E., & Lovenheim, M. F. (2012). The heterogeneous geographic and socioeconomic incidence of cigarette taxes: Evidence from nielsen homescan data. *American Economic Journal: Economic Policy*, 4(4), 169–98.
- Krumpal, I. (2013). Determinants of social desirability bias in sensitive surveys: A literature review. *Quality & Quantity*, 47(4), 2025–2047.
- Lemmens, S. G., Schoffelen, P. F., Wouters, L., Born, J. M., Martens, M. J., Rutters, F., & Westerterp-Plantenga, M. S. (2009). Eating what you like induces a stronger decrease of ‘wanting’to eat. *Physiology & Behavior*, 98(3), 318–325.
- Lenoir, M., Serre, F., Cantin, L., & Ahmed, S. H. (2007). Intense sweetness surpasses cocaine reward. *PloS one*, 2(8), e698.
- Locander, W., Sudman, S., & Bradburn, N. (1976). An investigation of interview method, threat and response distortion. *Journal of the American Statistical Association*, 71(354), 269–275.
- Mensch, B. S., & Kandel, D. B. (1988). Underreporting of substance use in a national longitudinal youth cohort: Individual and interviewer effects. *Public Opinion Quarterly*, 52(1), 100–124.
- Peters, J. C., Beck, J., Cardel, M., Wyatt, H. R., Foster, G. D., Pan, Z., Wojtanowski, A. C., Vander Veur, S. S., Herring, S. J., Brill, C., et al. (2016). The effects of water and non-

- nutritive sweetened beverages on weight loss and weight maintenance: A randomized clinical trial. *Obesity*, 24(2), 297–304.
- Peters, J. C., Wyatt, H. R., Foster, G. D., Pan, Z., Wojtanowski, A. C., Vander Veur, S. S., Herring, S. J., Brill, C., & Hill, J. O. (2014). The effects of water and non-nutritive sweetened beverages on weight loss during a 12-week weight loss treatment program. *Obesity*, 22(6), 1415–1421.
- Popkin, B. M., & Hawkes, C. (2016). Sweetening of the global diet, particularly beverages: Patterns, trends, and policy responses. *The lancet Diabetes & endocrinology*, 4(2), 174–186.
- Silver, B. D., Anderson, B. A., & Abramson, P. R. (1986). Who overreports voting? *The American Political Science Review*, 613–624.
- Silver, L. D., Ng, S. W., Ryan-Ibarra, S., Taillie, L. S., Induni, M., Miles, D. R., Poti, J. M., & Popkin, B. M. (2017). Changes in prices, sales, consumer spending, and beverage consumption one year after a tax on sugar-sweetened beverages in berkeley, california, us: A before-and-after study. *PLoS medicine*, 14(4), e1002283.

Table 1: Summary statistics for Chicago DMA sample: demographics

	Control	Cook	Total
	%	%	%
Hours employment/week of male head of HH			
No male head	25.14	36.34	31.18
< 30	2.61	3.86	3.28
30 - 34	1.97	1.72	1.83
≥ 35	49.88	35.66	42.22
Not employed	20.40	22.42	21.49
Hours employment/week of female head of HH			
No female head	20.35	23.23	21.90
< 30	10.52	10.40	10.46
30 - 34	5.85	3.77	4.73
≥ 35	32.89	32.80	32.84
Not employed	30.39	29.79	30.07
Racial identity of the household			
White	78.78	60.08	68.70
Black	7.87	23.63	16.36
Asian	3.91	5.72	4.89
Other	9.44	10.57	10.05
Household income			
<\$35K	21.46	31.46	26.85
\$35K - \$59,999	18.33	21.11	19.83
\$60K - \$99,999	25.61	21.29	23.28
>\$100K	34.60	26.14	30.04
Age of the (female) head of household			
<35	14.86	16.36	15.67
35 - 49	31.55	27.58	29.41
50-64	35.90	31.37	33.46
65+	17.69	24.70	21.47
Education of the (female) head of household			
< HS	2.99	2.12	2.52
HS Grad	27.69	25.35	26.43
Some College	28.28	31.77	30.16
Bachelor's+	41.04	40.76	40.89
Household size, top-coded at 6			
Mean	2.58	2.27	2.44
Any children < 18	39.94	26.67	32.79
Households	1,076	965	2,041
Household-months	12,795	11,432	24,227

All person-level variables (race, age, education) take the value of the female head of household unless there is no female head, in which case the variables take the value of the male head of household. Control includes households that reside in the Chicago DMA outside of Cook County limits. Summary statistics take into account sampling weights.

Table 2: Effects of Cook County Beverage Tax on nutrients

Dependent Variable	During tax			4 months post tax		
	(1)	(2)	(3)	(4)	(5)	(6)
All sugar	-0.144*** (0.036)	-0.149** (0.052)	-0.163** (0.059)	-0.009 (0.036)	0.006 (0.047)	0.013 (0.050)
Carbohydrates	-0.104** (0.034)	-0.111* (0.049)	-0.119* (0.055)	-0.020 (0.034)	-0.010 (0.044)	-0.004 (0.045)
Carb., non-sugar	-0.059 (0.037)	-0.077 (0.047)	-0.064 (0.051)	-0.026 (0.038)	-0.017 (0.051)	-0.014 (0.050)
Calories	-0.081* (0.036)	-0.092 (0.053)	-0.096 (0.060)	-0.022 (0.035)	-0.013 (0.048)	-0.004 (0.047)
Calories, non-sugar	-0.057 (0.043)	-0.087 (0.059)	-0.056 (0.059)	-0.047 (0.040)	-0.058 (0.066)	0.021 (0.066)
Fat	-0.045 (0.030)	-0.056 (0.041)	-0.035 (0.043)	-0.025 (0.031)	-0.035 (0.043)	-0.012 (0.045)
Fiber	-0.063* (0.027)	-0.060 (0.036)	-0.060 (0.040)	-0.021 (0.029)	-0.017 (0.038)	-0.014 (0.039)
Protein	-0.070* (0.031)	-0.088* (0.041)	-0.078 (0.044)	-0.029 (0.032)	-0.034 (0.045)	-0.010 (0.045)
Sodium	-0.060* (0.024)	-0.054 (0.030)	-0.046 (0.032)	-0.005 (0.024)	-0.004 (0.032)	-0.005 (0.035)
Treated Households	1142	1142	719	1220	1220	624
Households	2400	2400	1530	2575	2575	1302
Household-months	30272	30272	22950	29831	29831	19530
Balanced Panel	No	No	Yes	No	No	Yes
Sampling Weights	No	Yes	Yes	No	Yes	Yes

Note: Coefficients represent the percent change in the dependent variable during the four months that the Cook County beverage tax was active (1 - 3) and the four months after the tax was no longer active (4 - 6) relative to the 12 months preceding the tax, omitting the month prior to the tax. All specifications include household and month fixed effects. Standard errors in parentheses are clustered at the zip code level. ***, **, and * indicate significance at the 1, 5, and 10 percent critical levels, respectively.

Table 3: Effects of Cook County Beverage Tax on select beverage volume

Dependent Variable	During tax			4 months post tax		
	(1)	(2)	(3)	(4)	(5)	(6)
Reg. soda	-0.332*** (0.083)	-0.376*** (0.101)	-0.391*** (0.114)	0.062 (0.083)	0.057 (0.103)	0.106 (0.121)
Diet soda	-0.270*** (0.078)	-0.226* (0.096)	-0.143 (0.108)	0.031 (0.079)	0.016 (0.099)	0.084 (0.117)
Fruit drinks	-0.348*** (0.071)	-0.305** (0.093)	-0.355*** (0.107)	-0.054 (0.080)	-0.042 (0.102)	-0.014 (0.127)
Milk	-0.044 (0.067)	0.040 (0.095)	0.050 (0.110)	-0.024 (0.066)	-0.086 (0.098)	-0.081 (0.112)
Bottled water	0.085 (0.080)	0.124 (0.109)	0.148 (0.134)	-0.033 (0.086)	-0.132 (0.122)	-0.153 (0.145)
Alcohol	0.080 (0.055)	0.051 (0.075)	-0.001 (0.089)	0.075 (0.061)	0.137 (0.077)	0.147 (0.094)
Liquid tea	-0.202*** (0.057)	-0.184* (0.082)	-0.248** (0.087)	-0.025 (0.061)	-0.055 (0.084)	-0.065 (0.102)
Liquid coffee	-0.020 (0.031)	0.002 (0.038)	-0.024 (0.041)	-0.020 (0.027)	-0.021 (0.036)	-0.041 (0.041)
Solid coffee	0.031 (0.035)	0.084* (0.040)	0.055 (0.047)	-0.000 (0.042)	0.046 (0.050)	0.047 (0.059)
Treated Households	1142	1142	719	1220	1220	624
Households	2400	2400	1530	2575	2575	1302
Household-months	30272	30272	22950	29831	29831	19530
Balanced Panel	No	No	Yes	No	No	Yes
Sampling Weights	No	Yes	Yes	No	Yes	Yes

Note: Coefficients represent the percent change in the dependent variable during the four months that the Cook County beverage tax was active (1 - 3) and the four months after the tax was no longer active (4 - 6) relative to the 12 months preceding the tax, omitting the month prior to the tax. All specifications include household and month fixed effects. Standard errors in parentheses are clustered at the zip code level. ***, **, and * indicate significance at the 1, 5, and 10 percent critical levels, respectively.

Table 4: Effects of Cook County Beverage Tax on probability of purchasing select beverages

Dependent Variable	During tax			4 months post tax		
	(1)	(2)	(3)	(4)	(5)	(6)
Reg. soda	-0.051*** (0.014)	-0.059*** (0.017)	-0.066*** (0.019)	0.009 (0.014)	0.011 (0.017)	0.015 (0.021)
Diet soda	-0.038** (0.012)	-0.034* (0.015)	-0.020 (0.017)	0.003 (0.013)	-0.000 (0.017)	0.006 (0.020)
Fruit drinks	-0.055*** (0.013)	-0.048** (0.016)	-0.055** (0.018)	-0.017 (0.014)	-0.025 (0.018)	-0.023 (0.022)
Milk	-0.008 (0.011)	0.008 (0.015)	0.009 (0.018)	-0.007 (0.011)	-0.018 (0.016)	-0.018 (0.018)
Bottled water	0.012 (0.012)	0.019 (0.017)	0.023 (0.020)	-0.002 (0.013)	-0.014 (0.019)	-0.020 (0.022)
Alcohol	0.013 (0.010)	0.009 (0.013)	0.002 (0.016)	0.014 (0.011)	0.027* (0.014)	0.035* (0.017)
Liquid tea	-0.040*** (0.010)	-0.034* (0.015)	-0.041** (0.016)	-0.011 (0.012)	-0.016 (0.016)	-0.016 (0.020)
Liquid coffee	-0.005 (0.008)	-0.001 (0.009)	-0.010 (0.010)	-0.006 (0.006)	-0.006 (0.009)	-0.010 (0.010)
Solid coffee	0.007 (0.009)	0.019 (0.010)	0.013 (0.012)	-0.004 (0.010)	0.010 (0.012)	0.012 (0.014)
Treated Households	1142	1142	719	1220	1220	624
Households	2400	2400	1530	2575	2575	1302
Household-months	30272	30272	22950	29831	29831	19530
Balanced Panel	No	No	Yes	No	No	Yes
Sampling Weights	No	Yes	Yes	No	Yes	Yes

Note: Coefficients represent the change in probability of purchasing the dependent variable during the four months that the Cook County beverage tax was active (1 - 3) and the four months after the tax was no longer active (4 - 6) relative to the 12 months preceding the tax, omitting the month prior to the tax. All specifications include household and month fixed effects. Standard errors in parentheses are clustered at the zip code level. ***, **, and * indicate significance at the 1, 5, and 10 percent critical levels, respectively.

Table 5: Effects of Cook County Beverage Tax on sugar from select sources

Dependent Variable	During tax			4 months post tax		
	(1)	(2)	(3)	(4)	(5)	(6)
All sugar	-80.972** (28.789)	-92.053* (37.169)	-92.691* (40.755)	31.785 (30.574)	42.950 (40.479)	30.561 (44.589)
Sugar from reg. soda	-55.588* (22.220)	-74.164** (28.337)	-56.092 (31.843)	11.969 (22.699)	-1.145 (29.410)	-4.064 (32.745)
Sugar from fruit drinks	-16.486** (5.026)	-15.938* (6.652)	-23.496** (7.710)	9.198 (5.454)	18.647* (7.847)	16.209 (9.614)
Sugar from milk	-0.506 (0.723)	-0.696 (0.965)	-0.375 (1.096)	0.860 (0.783)	0.989 (1.027)	0.582 (1.180)
Sugar from liq. tea	-4.131 (2.420)	-3.826 (3.429)	-6.714 (3.752)	2.034 (2.584)	-0.273 (3.025)	-0.952 (3.887)
Sugar from liq. coffee	-0.230 (0.525)	0.280 (0.664)	0.381 (0.676)	-0.092 (0.528)	-0.276 (0.719)	-0.588 (0.735)
Sugar from sweets	1.342 (3.973)	3.318 (5.906)	5.109 (6.394)	-4.873 (4.615)	4.417 (6.849)	2.734 (8.123)
Treated Households	1142	1142	719	1220	1220	624
Households	2400	2400	1530	2575	2575	1302
Household-months	30272	30272	22950	29831	29831	19530
Balanced Panel	No	No	Yes	No	No	Yes
Sampling Weights	No	Yes	Yes	No	Yes	Yes

Note: Coefficients represent the absolute change in the dependent variable during the four months that the Cook County beverage tax was active (1 - 3) and the four months after the tax was no longer active (4 - 6) relative to the 12 months preceding the tax, omitting the month prior to the tax. All specifications include household and month fixed effects. Standard errors in parentheses are clustered at the zip code level. ***, **, and * indicate significance at the 1, 5, and 10 percent critical levels, respectively.

Table 6: Effects of Cook County Beverage Tax on panelist behaviors

Dependent Variable	During tax			4 months post tax		
	(1)	(2)	(3)	(4)	(5)	(6)
All Trips	-0.012 (0.015)	-0.004 (0.022)	0.004 (0.024)	0.002 (0.017)	0.000 (0.022)	0.003 (0.024)
All expenditures	-0.027 (0.017)	-0.021 (0.023)	-0.008 (0.025)	-0.019 (0.018)	-0.010 (0.023)	0.004 (0.024)
Expenditures scanned	-0.026 (0.017)	-0.017 (0.024)	-0.011 (0.027)	-0.012 (0.018)	-0.013 (0.023)	-0.001 (0.025)
Food expenditures scanned	-0.053* (0.026)	-0.041 (0.035)	-0.040 (0.039)	-0.001 (0.026)	-0.006 (0.034)	0.012 (0.034)
Items scanned	-0.040* (0.018)	-0.024 (0.024)	-0.012 (0.028)	-0.011 (0.019)	-0.001 (0.026)	0.001 (0.027)
Food items scanned	-0.064** (0.024)	-0.050 (0.032)	-0.038 (0.036)	-0.013 (0.025)	-0.007 (0.033)	0.004 (0.034)
Storebrand items scanned	-0.082* (0.032)	-0.100* (0.041)	-0.098* (0.047)	-0.064 (0.034)	-0.077 (0.044)	-0.085 (0.050)
Items with coupon scanned	-0.013 (0.024)	-0.001 (0.031)	0.023 (0.033)	-0.009 (0.029)	0.014 (0.038)	0.053 (0.045)
Items with deals scanned	-0.018 (0.031)	0.009 (0.043)	0.062 (0.047)	0.024 (0.036)	0.043 (0.050)	0.053 (0.052)
Treated Households	1142	1142	719	1220	1220	624
Households	2400	2400	1530	2575	2575	1302
Household-months	30272	30272	22950	29831	29831	19530
Balanced Panel	No	No	Yes	No	No	Yes
Sampling Weights	No	Yes	Yes	No	Yes	Yes

Note: Coefficients represent the percent change in the dependent variable during the four months that the Cook County beverage tax was active (1 - 3) and the four months after the tax was no longer active (4 - 6) relative to the 12 months preceding the tax, omitting the month prior to the tax. All specifications include household and month fixed effects. Standard errors in parentheses are clustered at the zip code level. ***, **, and * indicate significance at the 1, 5, and 10 percent critical levels, respectively.

Table 7: Heterogeneous treatment effects of tax by household characteristics

	Sugar (g)	Reg. soda (oz)
Panel A: Household income		
\$35K - \$59,999	0.062 (0.102)	-0.332 (0.183)
\$60K - \$99,999	0.007 (0.090)	-0.086 (0.131)
>\$100K	0.078 (0.089)	0.115 (0.182)
Panel B: Household race		
Black	0.024 (0.075)	-0.135 (0.171)
Asian	0.021 (0.130)	-0.089 (0.232)
Other	-0.213 (0.169)	-0.418 (0.219)
Panel C: Household education		
Some College	-0.025 (0.097)	0.220 (0.164)
BA+	0.043 (0.074)	0.506** (0.155)
Treated Households	1142	1142
Households	2400	2400
Household-months	30272	30272
Balanced Panel	No	No
Sampling Weights	Yes	Yes

Note: Coefficients represent the percent change in the dependent variable for those with the given household characteristic during the four months that the Cook County beverage tax was active relative to the 12 months preceding the tax, omitting the month prior to the tax. Omitted categories are income under \$35K, race = White, and education = HS grad or less. All specifications include household and month fixed effects. Standard errors in parentheses are clustered at the zip code level. ***, **, and * indicate significance at the 1, 5, and 10 percent critical levels, respectively.

Table 8: Effects of Cook County Beverage Tax by zip code layer

Zip layer	During tax		
	(1)	(2)	(3)
Border zips	-0.086 (0.054)	-0.070 (0.070)	-0.109 (0.079)
Middle layer	-0.156** (0.050)	-0.140* (0.066)	-0.187* (0.072)
Innermost layer	-0.188* (0.078)	-0.187 (0.098)	-0.140 (0.106)
Treated Households	884	884	587
Households	1862	1862	1253
Household-months	24108	24108	18795
Balanced Panel	No	No	Yes
Sampling Weights	No	Yes	Yes

Note: Coefficients represent the percent change in sugar purchased during the four months that the Cook County beverage tax was active, separated by zip code layer within Cook County. The omitted group is zip codes outside of Cook County, and the specification does not include zip codes that cross the border. The sample includes only households that have positive purchases of regular soda during the year prior to the tax, omitting the month prior to the tax. All specifications include household and month fixed effects. Standard errors in parentheses are clustered at the zip code level. ***, **, and * indicate significance at the 1, 5, and 10 percent critical levels, respectively.

Table 9: Effects of Cook County Beverage Tax on cross-border All Trips

Dependent Variable	During tax			4 months post tax		
	(1)	(2)	(3)	(4)	(5)	(6)
IB trips	-0.045** (0.017)	-0.022 (0.022)	-0.025 (0.025)	0.004 (0.017)	0.014 (0.022)	0.009 (0.025)
CB trips	0.028 (0.020)	0.026 (0.028)	0.036 (0.033)	0.010 (0.021)	-0.008 (0.026)	-0.013 (0.030)
IB expenditures	-0.092** (0.029)	-0.057 (0.031)	-0.049 (0.032)	-0.023 (0.024)	-0.005 (0.030)	-0.005 (0.032)
CB expenditures	-0.019 (0.041)	-0.014 (0.063)	0.021 (0.072)	-0.035 (0.042)	-0.067 (0.055)	-0.036 (0.064)
IB sugar	-0.217*** (0.045)	-0.208*** (0.057)	-0.205** (0.064)	-0.023 (0.042)	-0.003 (0.055)	-0.003 (0.059)
CB sugar	0.088 (0.064)	0.103 (0.088)	0.069 (0.100)	0.100 (0.053)	0.102 (0.069)	0.061 (0.087)
Treated Households	1142	1142	719	1220	1220	624
Households	2400	2400	1530	2575	2575	1302
Household-months	30272	30272	22950	29831	29831	19530
Balanced Panel	No	No	Yes	No	No	Yes
Sampling Weights	No	Yes	Yes	No	Yes	Yes

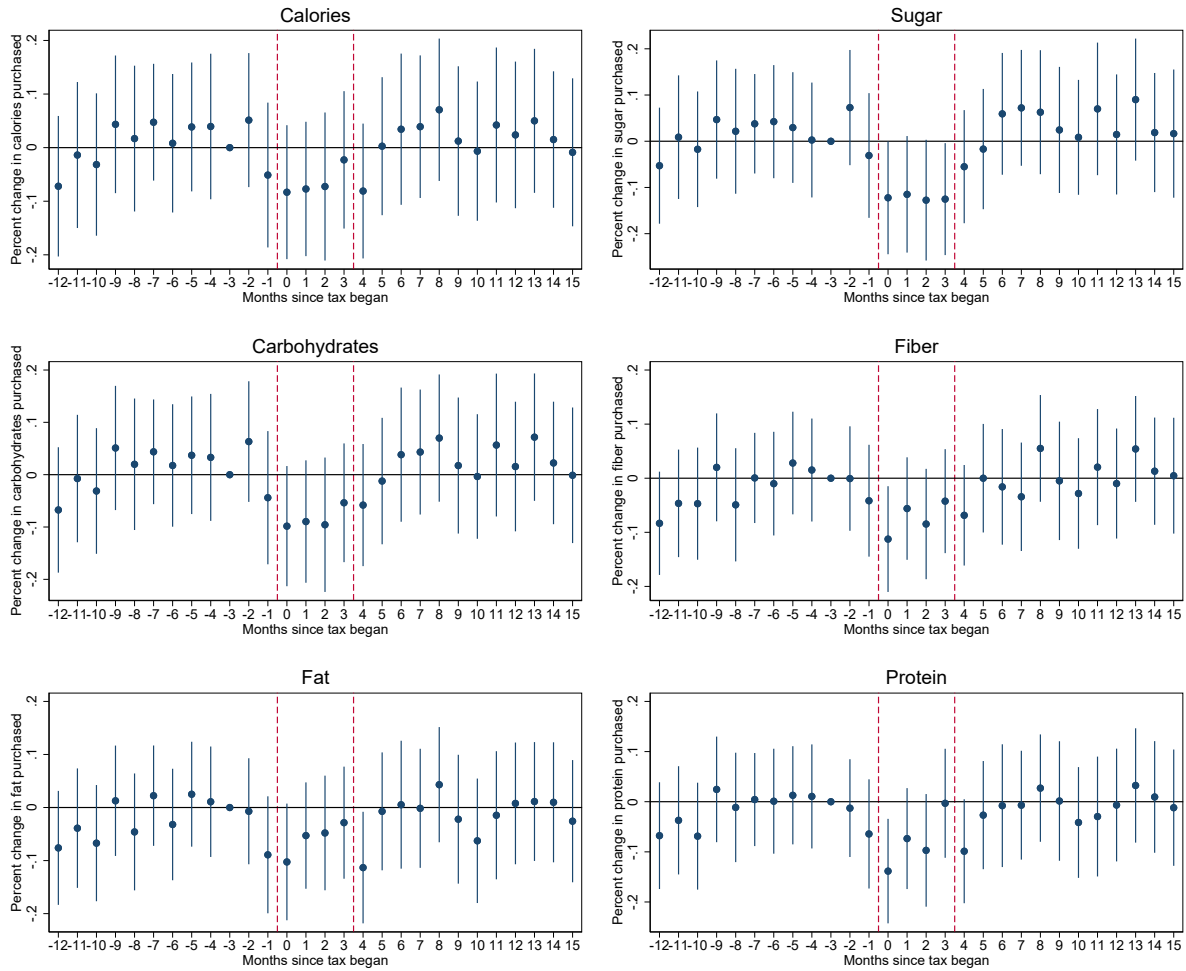
Note: IB = Inside Border, CB = Cross Border. Coefficients represent the percent change in the dependent variable during the four months that the Cook County beverage tax was active (1 - 3) and the four months after the tax was no longer active (4 - 6) relative to the 12 months preceding the tax, omitting the month prior to the tax. All specifications include household and month fixed effects. Standard errors in parentheses are clustered at the zip code level. ***, **, and * indicate significance at the 1, 5, and 10 percent critical levels, respectively.

Table 10: Effects of tax on sugar by pretreatment soda decile, Cook County

Pre-tax soda decile	Sugar during tax			Sugar 4 months post tax		
	(1)	(2)	(3)	(4)	(5)	(6)
Deciles 1 - 2	-0.051 (0.061)	-0.106 (0.086)	-0.108 (0.097)	0.129 (0.070)	0.131 (0.092)	0.110 (0.087)
Decile 3	0.065 (0.072)	0.098 (0.082)	0.003 (0.092)	0.046 (0.101)	0.145 (0.138)	0.114 (0.168)
Decile 4	-0.082 (0.066)	-0.013 (0.084)	-0.040 (0.098)	0.093 (0.066)	0.190* (0.089)	0.059 (0.087)
Decile 5	-0.156 (0.089)	-0.088 (0.110)	-0.119 (0.140)	-0.042 (0.072)	0.043 (0.080)	0.039 (0.067)
Decile 6	-0.022 (0.087)	-0.079 (0.174)	-0.198 (0.215)	0.048 (0.067)	0.092 (0.085)	0.114 (0.101)
Decile 7	-0.185** (0.070)	-0.141 (0.096)	-0.168 (0.098)	0.050 (0.077)	0.056 (0.107)	-0.005 (0.089)
Decile 8	-0.291** (0.109)	-0.269** (0.096)	-0.083 (0.076)	-0.089 (0.088)	-0.138 (0.091)	-0.121 (0.099)
Decile 9	-0.326*** (0.084)	-0.345*** (0.100)	-0.439*** (0.104)	-0.016 (0.072)	0.016 (0.097)	0.084 (0.126)
Decile 10	-0.340*** (0.074)	-0.311*** (0.084)	-0.290** (0.089)	-0.034 (0.082)	-0.044 (0.122)	-0.029 (0.107)
Treated Households	1142	1142	720	1220	1220	625
Households	2400	2400	1535	2575	2575	1304
Household-months	30272	30272	23025	37909	37909	24776
Balanced Panel	No	No	Yes	No	No	Yes
Sampling Weights	No	Yes	Yes	No	Yes	Yes

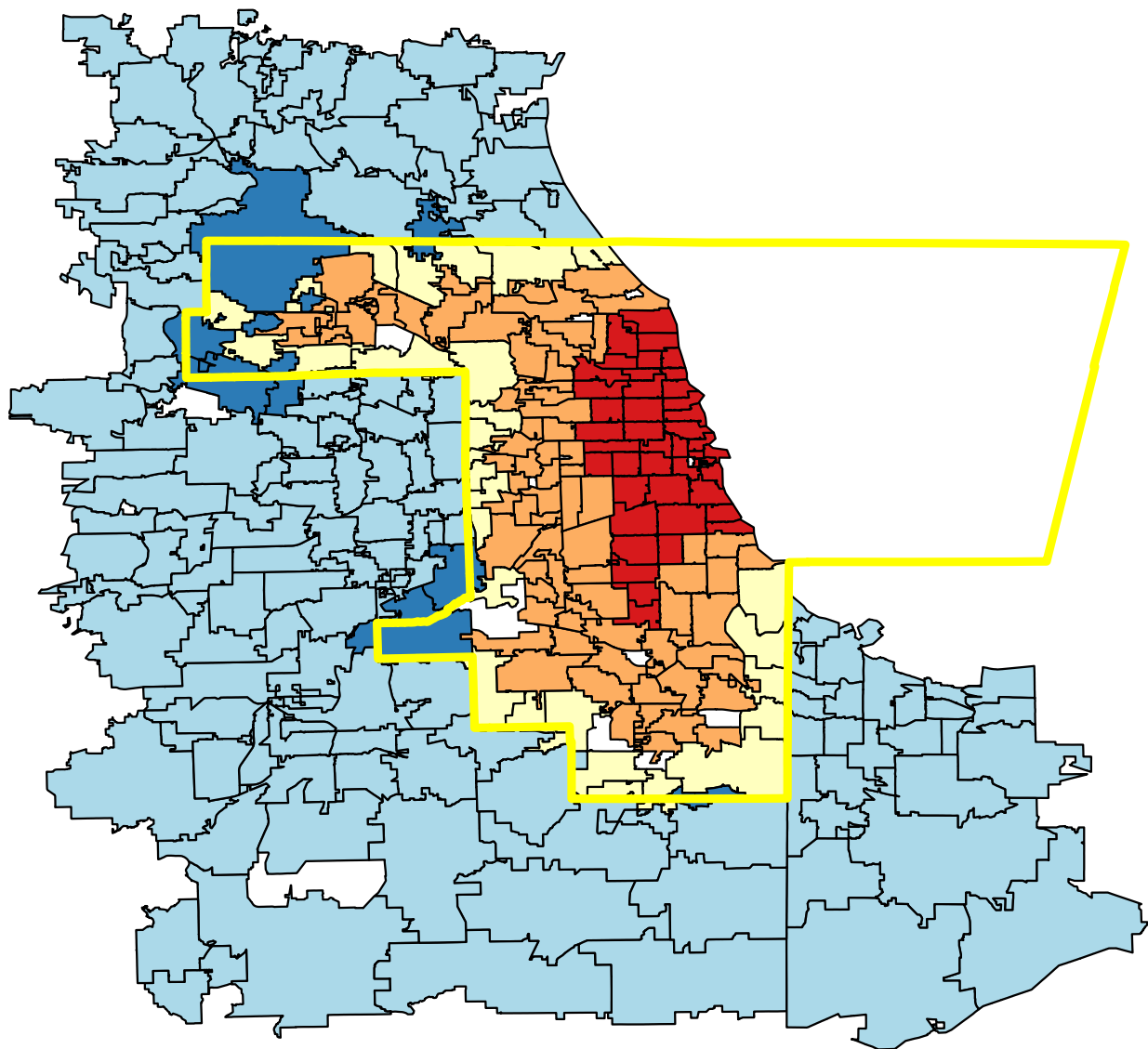
Note: Coefficients represent the percent change in sugar purchased during the four months that the Cook County beverage tax was active (1 - 3) and the four months after the tax was no longer active (4 - 6), separated by expenditure-weighted pretreatment regular soda volume purchase decile. We omit the month prior to the tax to reduce bias from anticipatory effects. Deciles were calculated based on the treated households' average monthly volume of soda purchased during the previous year omitting the month prior to the tax. All of deciles 1 and 2 report zero regular soda purchases before the tax. All specifications include household and month fixed effects. Standard errors in parentheses are clustered at the zip code level. ***, **, and * indicate significance at the 1, 5, and 10 percent critical levels, respectively.

Figure 2: Effects of Cook County tax on nutrients purchased



Each panel displays the monthly differences in log quantities purchased by residents of Cook County, Illinois and those in the same DMA outside of the county limits. The regressions used include household and month fixed-effects, and errors are clustered and the zip-code level. Vertical dashed lines represent the start and end of the tax in Cook County.

Figure 3: Cook County zip code layers



Zip code layers used for examining heterogeneous treatment effects by distance from the nearest border.

White regions in the map have no corresponding zip code information (lakes, forest, and other land without mailing addresses) and hence are excluded from the analysis. The darkest blue zip codes contain households both inside and outside Cook County's border. The lighter-yellow zips lie on the border entirely within Cook County. The remaining layers are constructed using linear distance to the nearest untaxed zip.

Figure 4: Soda budget share and price

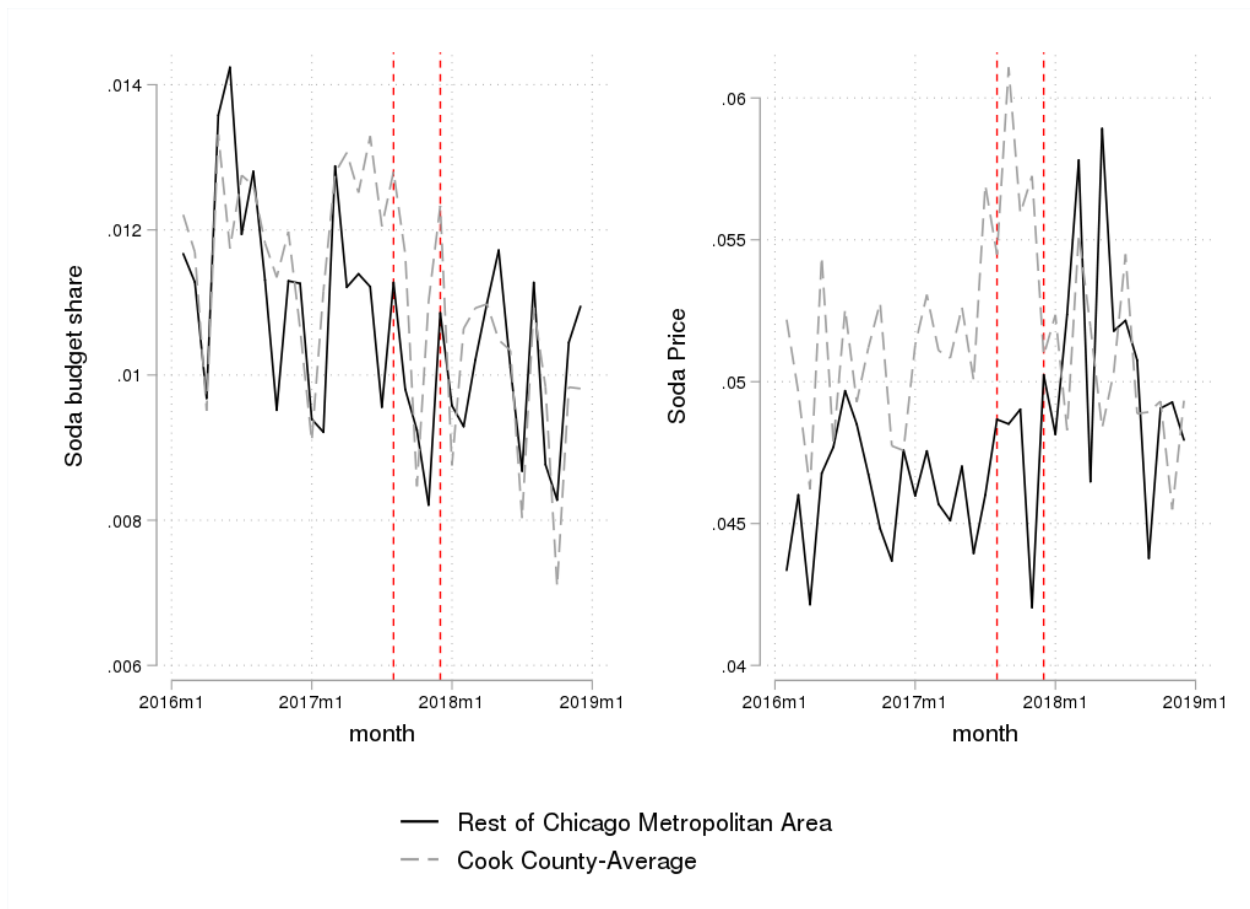
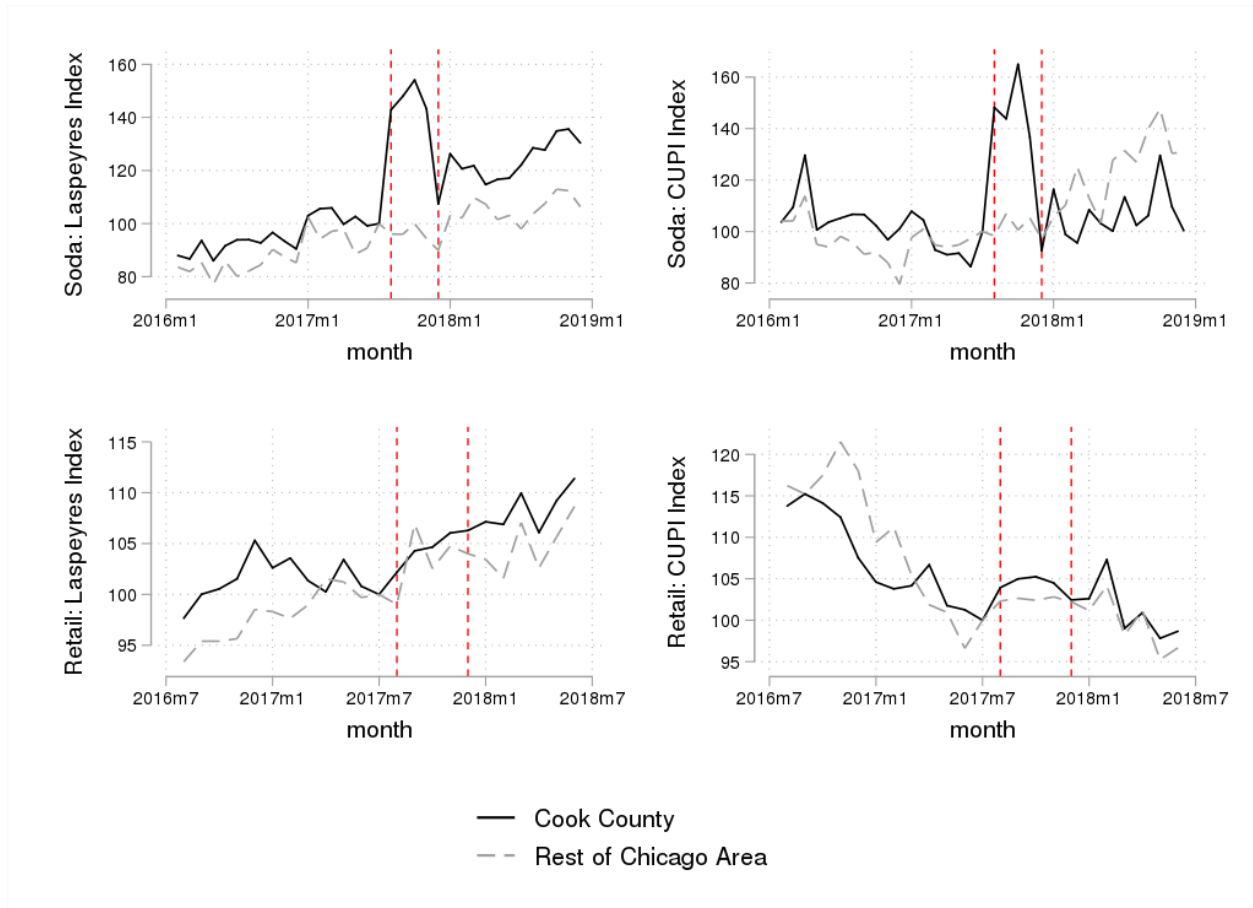


Figure 5: Price indices



Note: The top row shows the change in the soda only price index in Cook County and the rest of the Chicago Area. The bottom row shows the full retail price index. The right side assumes that households have nested CES preferences with time varying taste parameters, while the left hand-side is a simple Laspeyres weighted index. All price indices are set at 100 in July 2017.

Appendix

Table A1: Summary statistics by soda decile, Cook County

	Reg. soda (oz)	Sugar (g)	Sugar from soda (g)	Trips	Items scanned	Total spent (\$)	Hh. size
Deciles 1 - 2	0.00 (0.00)	442.04 (448.05)	0.00 (0.00)	11.45 (9.51)	81.75 (53.41)	456.29 (362.63)	2.00 (1.18)
Decile 3	7.38 (23.59)	560.01 (576.91)	11.62 (48.87)	11.54 (6.93)	99.98 (62.91)	505.12 (325.10)	2.12 (1.15)
Decile 4	25.07 (62.62)	674.40 (603.01)	46.28 (144.72)	14.25 (9.97)	108.58 (70.41)	567.62 (392.79)	2.04 (1.02)
Decile 5	52.11 (120.54)	793.11 (779.81)	110.68 (350.65)	13.79 (8.88)	117.54 (75.19)	601.94 (584.85)	2.31 (1.30)
Decile 6	85.38 (159.70)	861.31 (902.21)	186.44 (430.67)	15.49 (14.58)	108.42 (72.25)	584.54 (426.79)	2.21 (1.21)
Decile 7	133.10 (215.90)	983.27 (991.17)	293.43 (628.80)	12.36 (8.46)	114.14 (74.32)	556.78 (420.58)	2.64 (1.34)
Decile 8	224.79 (290.68)	1300.58 (1274.11)	575.75 (923.06)	13.83 (9.86)	116.80 (75.06)	564.61 (401.53)	2.39 (1.23)
Decile 9	371.25 (446.85)	1743.45 (1622.65)	904.20 (1287.80)	14.15 (11.24)	134.41 (99.54)	558.40 (421.21)	2.55 (1.37)
Decile 10	729.56 (704.40)	2490.04 (2035.11)	1959.81 (2259.00)	12.17 (8.53)	114.15 (73.93)	454.44 (339.24)	2.28 (1.26)

Note: Deciles are calculated using each household's average monthly soda volume purchased per dollar spent during the year prior to the tax, omitting the month prior to the tax. Standard deviations in parentheses.

Table A2: Effects of tax on sugar by pretreatment soda quintile, Seattle and San Francisco

Pre-tax soda quintile	Months 1 - 4, sugar			Months 5 - 8, sugar		
	(1)	(2)	(3)	(4)	(5)	(6)
Quintiles 1 - 2	0.053 (0.085)	-0.144 (0.142)	-0.172 (0.142)	0.065 (0.097)	-0.001 (0.135)	0.093 (0.138)
Quintile 3	0.150 (0.129)	0.099 (0.148)	0.070 (0.164)	0.061 (0.144)	0.258 (0.193)	0.187 (0.211)
Quintile 4	-0.021 (0.105)	-0.116 (0.139)	-0.172 (0.148)	-0.180 (0.156)	-0.336 (0.218)	-0.337 (0.238)
Quintile 5	-0.473** (0.148)	-0.596** (0.229)	-0.613** (0.237)	-0.098 (0.102)	-0.128 (0.189)	-0.161 (0.201)
Treated Households	229	229	153	229	229	151
Households	2141	2141	1402	2141	2141	1375
Household-months	27663	27663	21030	34932	34932	26125
Balanced Panel	No	No	Yes	No	No	Yes
Sampling Weights	No	Yes	Yes	No	Yes	Yes

Note: Coefficients represent the percent change in sugar purchased during the first four months (1 - 3) and second four months (4 - 6) after the Seattle and San Francisco beverage taxes became active, separated by expenditure-weighted pretreatment regular soda volume purchase decile. We omit the month prior to the tax to reduce bias from anticipatory effects. Quintiles were calculated based on the treated households' average monthly volume of soda purchased during the previous year omitting the month prior to the tax. All of quintile 1 and nearly all of quintile 2 report zero regular soda purchases before the tax. Standard errors in parentheses are clustered at the zip code level. ***, **, and * indicate significance at the 1, 5, and 10 percent critical levels, respectively.

Table A3: Effects of tax on sugar by pretreatment soda quintile, Philadelphia

Pre-tax soda quintile	Months 1 - 4, sugar			Months 5 - 8, sugar		
	(1)	(2)	(3)	(4)	(5)	(6)
Quintile 1	0.093 (0.078)	0.054 (0.094)	0.105 (0.090)	0.204 (0.139)	0.019 (0.170)	0.202 (0.114)
Quintile 2	0.218 (0.120)	0.313* (0.125)	0.355** (0.111)	0.212** (0.074)	0.212 (0.126)	0.160 (0.139)
Quintile 3	0.091 (0.081)	0.056 (0.107)	-0.006 (0.114)	-0.012 (0.099)	-0.011 (0.109)	0.046 (0.134)
Quintile 4	-0.252* (0.123)	-0.277 (0.154)	-0.228 (0.147)	-0.132 (0.094)	-0.044 (0.084)	-0.191 (0.105)
Quintile 5	-0.292* (0.140)	-0.330* (0.149)	-0.319* (0.153)	-0.247 (0.156)	-0.193 (0.176)	-0.200 (0.226)
Treated Households	262	262	149	262	262	146
Households	2012	2012	1228	2012	2012	1198
Household-months	25319	25319	18420	31937	31937	22762
Balanced Panel	No	No	Yes	No	No	Yes
Sampling Weights	No	Yes	Yes	No	Yes	Yes

Note: Coefficients represent the percent change in sugar purchased during the first four months (1 - 3) and second four months (4 - 6) after the Philadelphia beverage tax became active, separated by expenditure-weighted pretreatment regular soda volume purchase decile. Quintiles were calculated based on the treated households' average monthly volume of soda purchased during the previous year omitting the month prior to the tax. Nearly all of quintile 1 report zero regular soda purchases before the tax. Standard errors in parentheses are clustered at the zip code level. ***, **, and * indicate significance at the 1, 5, and 10 percent critical levels, respectively.

Table A4: Effects of Cook County Beverage Tax on nutrients, 10 largest counties by population as counterfactual

Dependent Variable	During tax			4 months post tax		
	(1)	(2)	(3)	(4)	(5)	(6)
All sugar	-0.129*** (0.031)	-0.087* (0.040)	-0.095* (0.043)	0.020 (0.030)	0.056 (0.036)	0.072 (0.039)
Carbohydrates	-0.069* (0.029)	-0.027 (0.037)	-0.031 (0.039)	0.020 (0.028)	0.048 (0.034)	0.052 (0.035)
Carb., non-sugar	0.033 (0.032)	0.061 (0.038)	0.056 (0.043)	0.042 (0.031)	0.062 (0.039)	0.053 (0.040)
Calories	-0.035 (0.031)	0.003 (0.039)	-0.003 (0.041)	0.018 (0.029)	0.044 (0.036)	0.043 (0.035)
Calories, non-sugar	0.028 (0.037)	0.056 (0.046)	0.059 (0.045)	0.028 (0.033)	0.042 (0.047)	0.047 (0.041)
Fat	0.007 (0.026)	0.053 (0.033)	0.052 (0.033)	0.027 (0.024)	0.052 (0.034)	0.044 (0.034)
Fiber	-0.011 (0.023)	0.037 (0.028)	0.034 (0.030)	0.041 (0.024)	0.069* (0.030)	0.062* (0.031)
Protein	-0.010 (0.027)	0.030 (0.032)	0.031 (0.034)	0.030 (0.026)	0.059 (0.035)	0.061 (0.034)
Sodium	-0.031 (0.021)	0.000 (0.024)	0.013 (0.025)	0.040* (0.020)	0.053* (0.025)	0.055* (0.026)
Treated Households	1142	1142	719	1220	1220	624
Households	7464	7464	4453	8250	8250	3804
Household-months	92291	92291	66795	91334	91334	57060
Balanced Panel	No	No	Yes	No	No	Yes
Sampling Weights	No	Yes	Yes	No	Yes	Yes

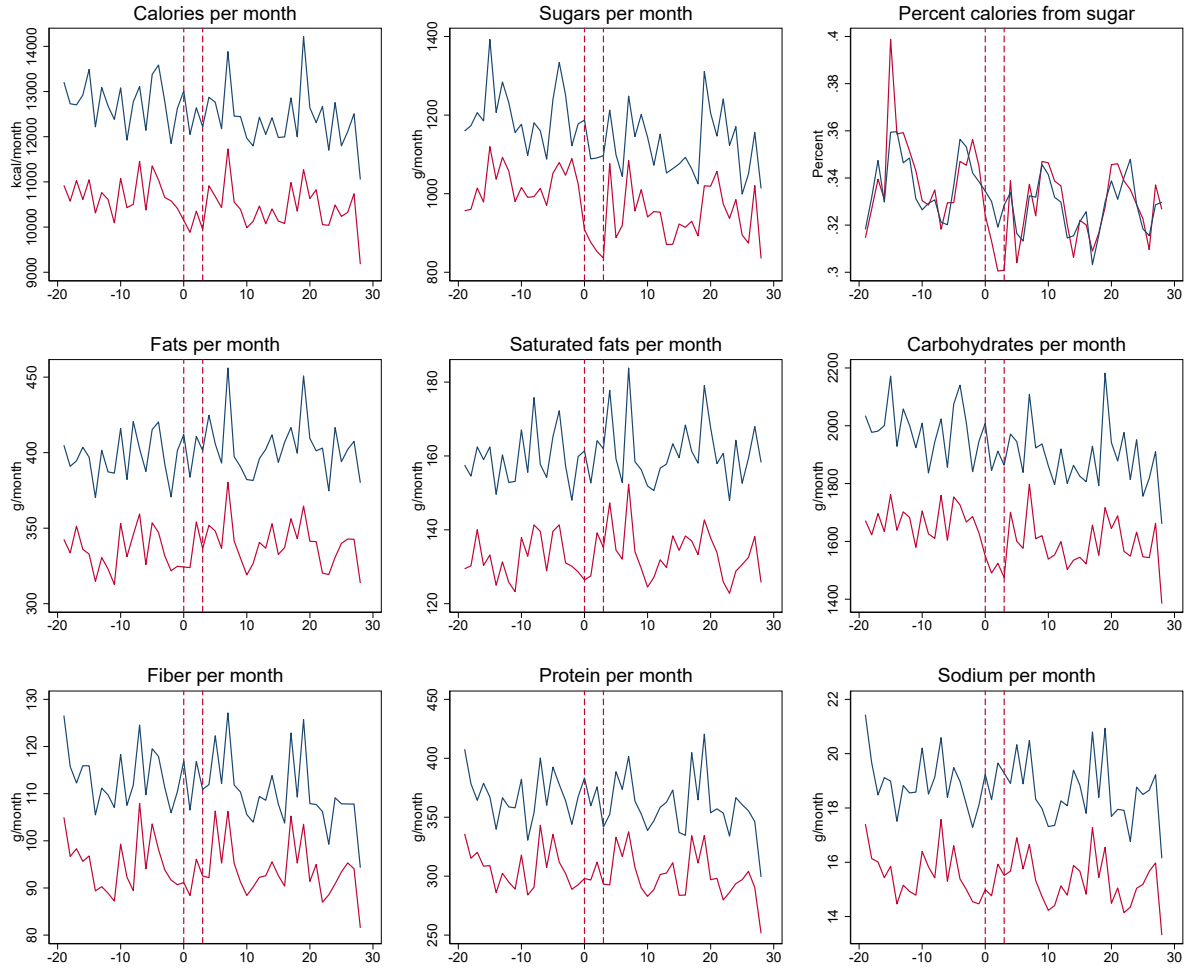
Note: Coefficients represent the percent change in the dependent variable during the four months that the Cook County beverage tax was active (1 - 3) and the four months after the tax was no longer active (4 - 6) relative to the 12 months preceding the tax, omitting the month prior to the tax. All specifications include household and month fixed effects. Standard errors in parentheses are clustered at the zip code level. ***, **, and * indicate significance at the 1, 5, and 10 percent critical levels, respectively.

Table A5: Effects of Cook County Beverage Tax on nutrients, 10 nearest population density counties as counterfactual

Dependent Variable	During tax			4 months post tax		
	(1)	(2)	(3)	(4)	(5)	(6)
All sugar	-0.117** (0.039)	-0.138** (0.050)	-0.104* (0.052)	-0.016 (0.039)	0.029 (0.050)	0.083 (0.058)
Carbohydrates	-0.089* (0.037)	-0.113* (0.047)	-0.072 (0.048)	-0.032 (0.037)	0.004 (0.048)	0.047 (0.056)
Carb., non-sugar	-0.022 (0.049)	-0.047 (0.054)	-0.008 (0.057)	-0.038 (0.050)	-0.002 (0.056)	0.013 (0.065)
Calories	-0.062 (0.038)	-0.085 (0.048)	-0.046 (0.049)	-0.045 (0.039)	-0.002 (0.051)	0.037 (0.057)
Calories, non-sugar	-0.001 (0.051)	-0.033 (0.056)	0.028 (0.056)	-0.029 (0.049)	0.030 (0.066)	0.053 (0.066)
Fat	0.005 (0.033)	0.002 (0.043)	0.044 (0.045)	-0.028 (0.034)	0.016 (0.046)	0.048 (0.053)
Fiber	-0.014 (0.033)	-0.021 (0.040)	-0.003 (0.043)	-0.024 (0.033)	0.007 (0.043)	0.032 (0.048)
Protein	-0.029 (0.035)	-0.034 (0.042)	0.005 (0.044)	-0.033 (0.038)	0.023 (0.051)	0.065 (0.058)
Sodium	-0.013 (0.026)	-0.010 (0.032)	0.025 (0.034)	-0.003 (0.027)	0.027 (0.036)	0.059 (0.043)
Treated Households	1142	1142	719	1220	1220	624
Households	1907	1907	1202	2059	2059	1029
Household-months	24004	24004	18030	23630	23630	15435
Balanced Panel	No	No	Yes	No	No	Yes
Sampling Weights	No	Yes	Yes	No	Yes	Yes

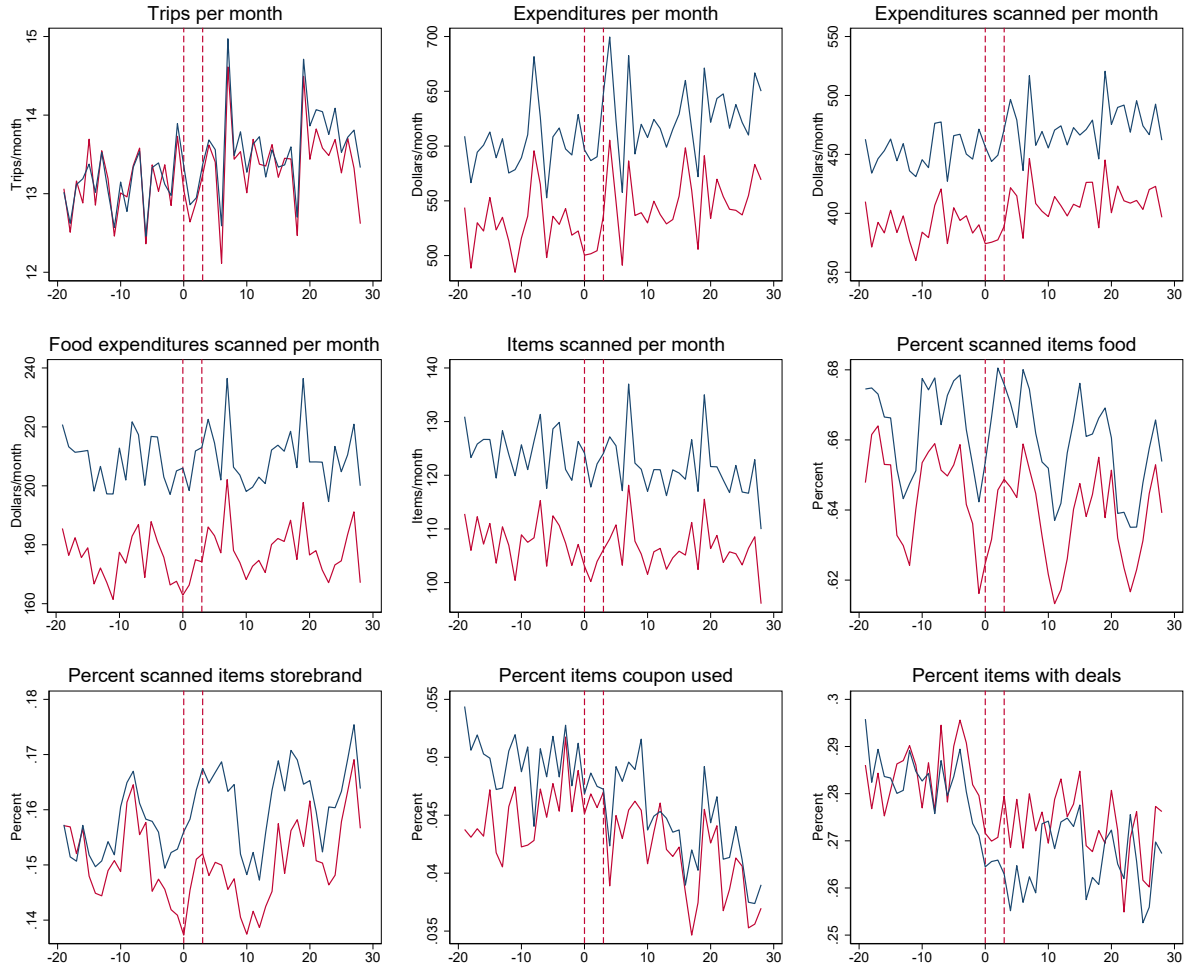
Note: Coefficients represent the percent change in the dependent variable during the four months that the Cook County beverage tax was active (1 - 3) and the four months after the tax was no longer active (4 - 6) relative to the 12 months preceding the tax, omitting the month prior to the tax. All specifications include household and month fixed effects. Standard errors in parentheses are clustered at the zip code level. ***, **, and * indicate significance at the 1, 5, and 10 percent critical levels, respectively.

Figure A1: Cook County DMA: nutrient composition over time



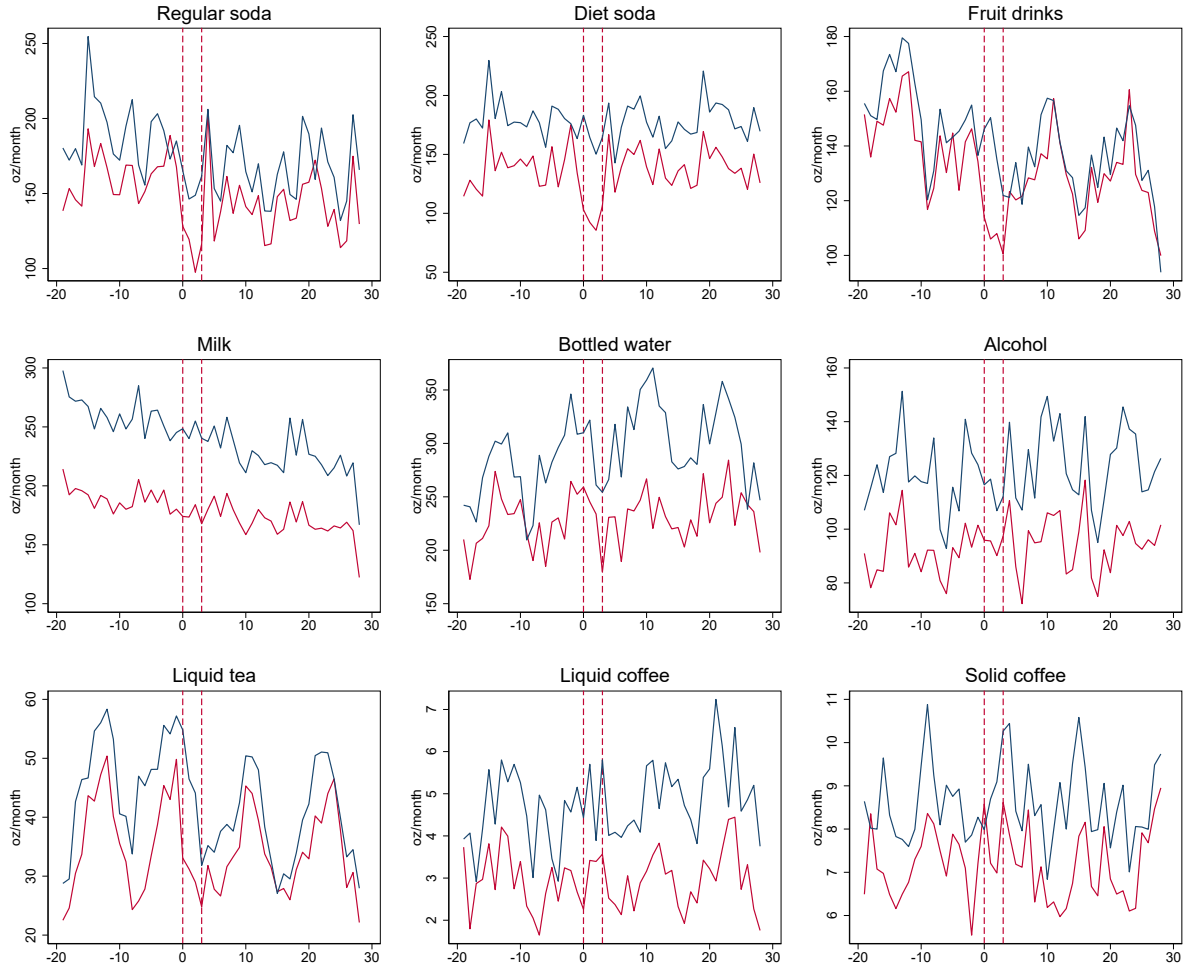
Each panel displays monthly sums or percentages of different nutrients for residents of Cook County, Illinois (red) and those in the same DMA outside of the county limits (blue). Vertical dashed lines represent the start and end of the tax in Cook County.

Figure A2: Cook County DMA: panelist behaviors over time



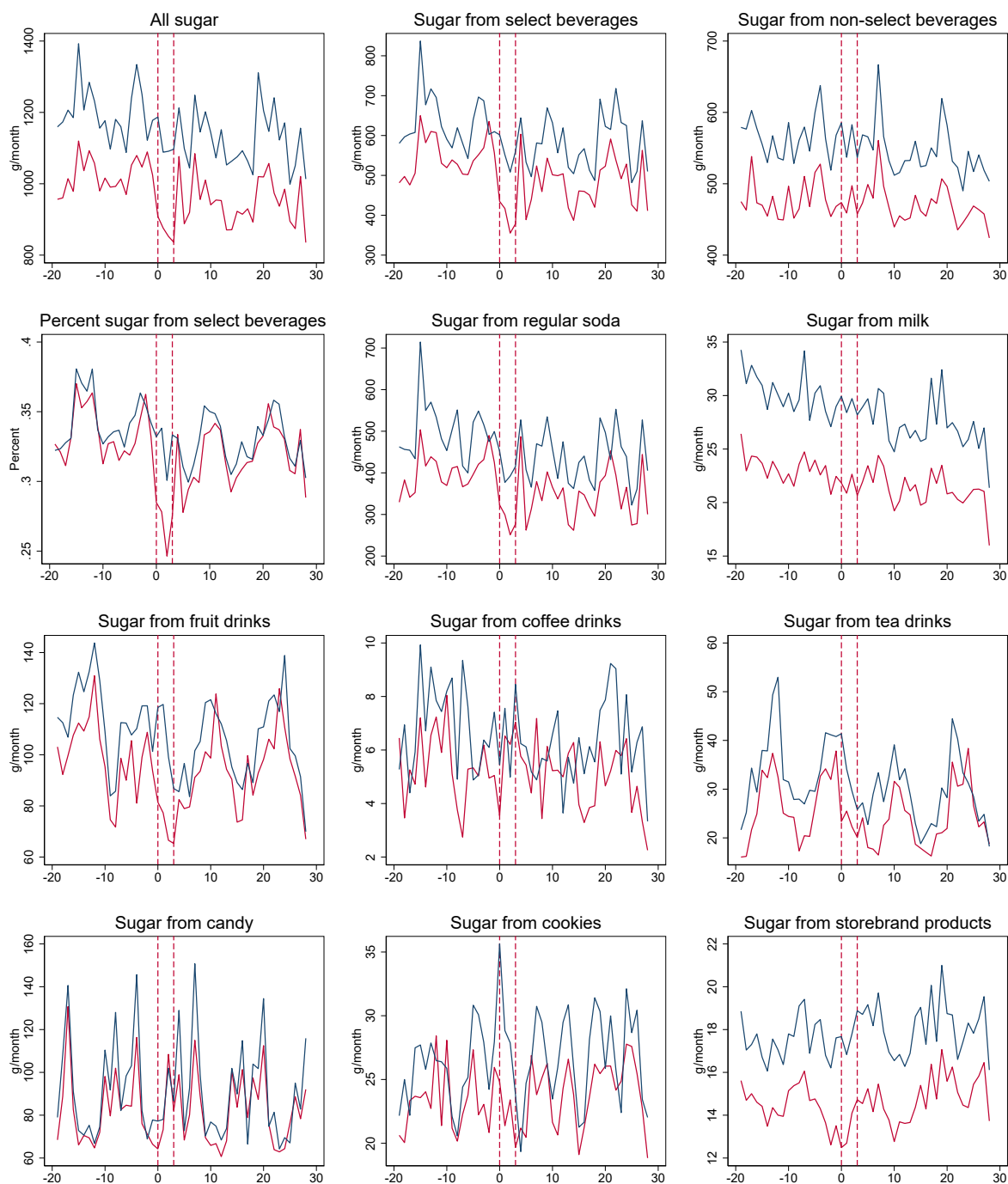
Each panel displays monthly sums or percentages of panelist behaviors for residents of Cook County, Illinois (red) and those in the same DMA outside of the county limits (blue). Vertical dashed lines represent the start and end of the tax in Cook County.

Figure A3: Cook County DMA: beverage purchases over time



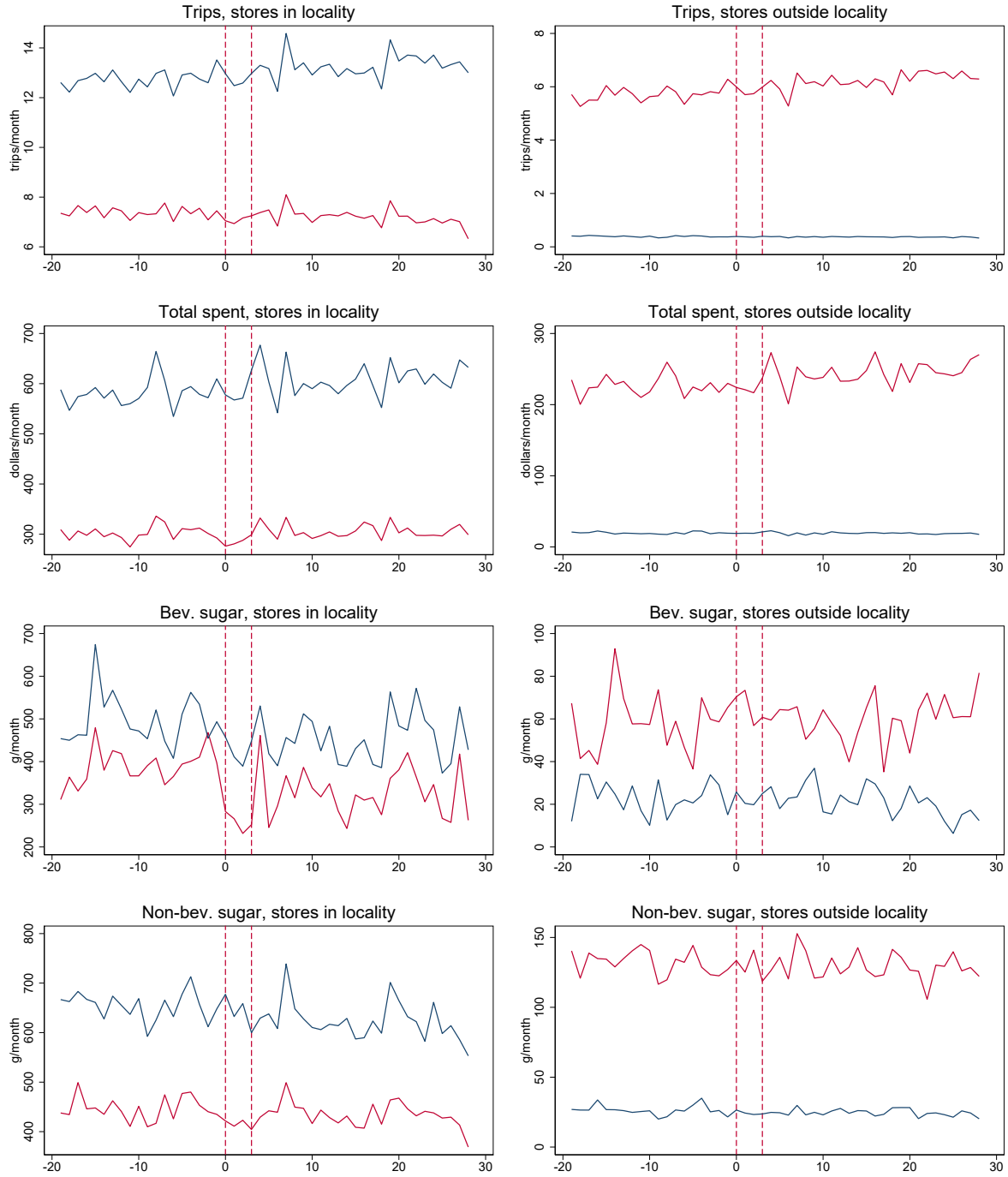
Each panel displays monthly sums of purchased beverages (in ounces) for residents of Cook County, Illinois (red) and those in the same DMA outside of the county limits (blue). Vertical dashed lines represent the start and end of the tax in Cook County.

Figure A4: Cook County DMA: sugar by source over time



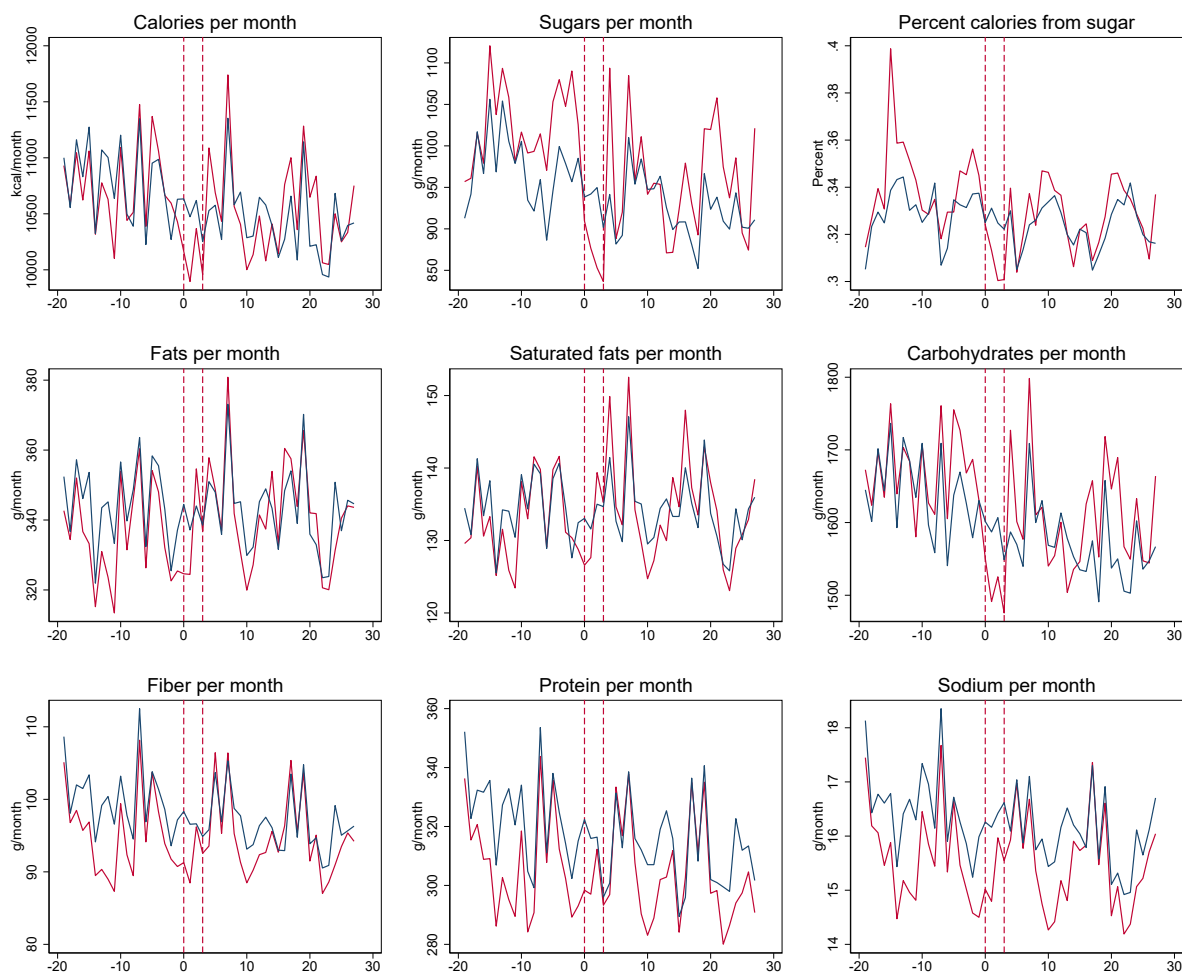
Each panel displays monthly sums of sugar (in grams) for residents of Cook County, Illinois (red) and those in the same DMA outside of the county limits (blue) from different product groups. Vertical dashed lines represent the start and end of the tax in Cook County.

Figure A5: Cook County DMA: variation by store location



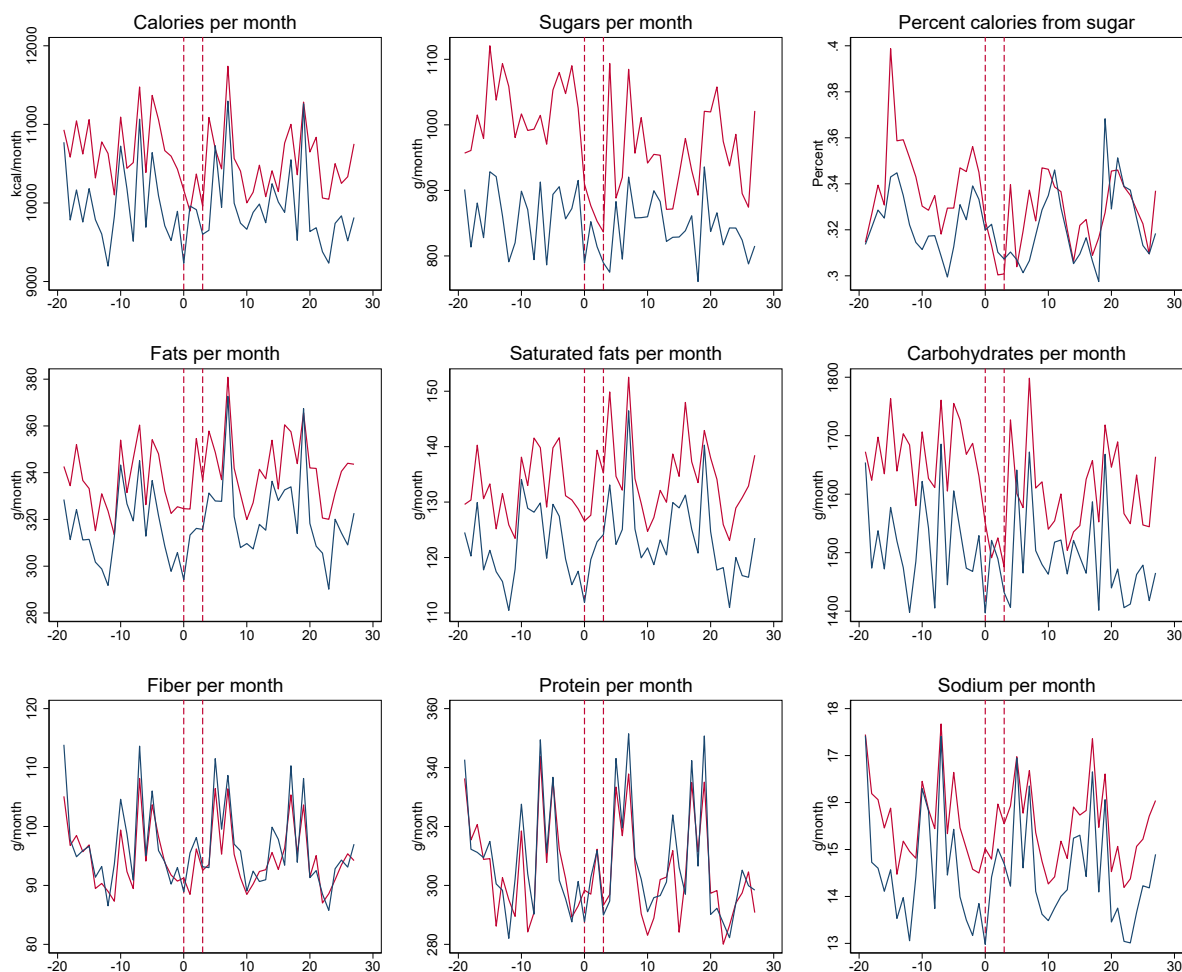
Each panel displays monthly sums of trips, total purchases, and grams of sugar (from beverages or non-beverages) for residents of Cook County, Illinois (red) and those in the same DMA outside of the county limits (blue). Left panels are sums within Cook County stores for Cook County residents and non-Cook County stores for control residents. Right panels show the reverse: sums within non-Cook County stores for Cook County residents and Cook County stores for control residents. Vertical dashed lines represent the start and end of the tax in Cook County.

Figure A6: Cook County DMA: nutrient composition over time, ten largest counties as counterfactual



Each panel displays monthly sums or percentages of different nutrients for residents of Cook County, Illinois (red) and those in the ten largest counties by population, excluding Cook County (blue). Vertical dashed lines represent the start and end of the tax in Cook County.

Figure A7: Cook County DMA: nutrient composition over time, ten nearest population density counties as counterfactual



Each panel displays monthly sums or percentages of different nutrients for residents of Cook County, Illinois (red) and those in the ten nearest counties by population density to Cook County (blue). Vertical dashed lines represent the start and end of the tax in Cook County.

Figure A8: Example price tag from Cook County grocery store



This price tag includes a warning about the beverage tax in Cook County. Price tags like these may have increased salience of the tax whereas price tags in smaller, non-chain stores may not have.

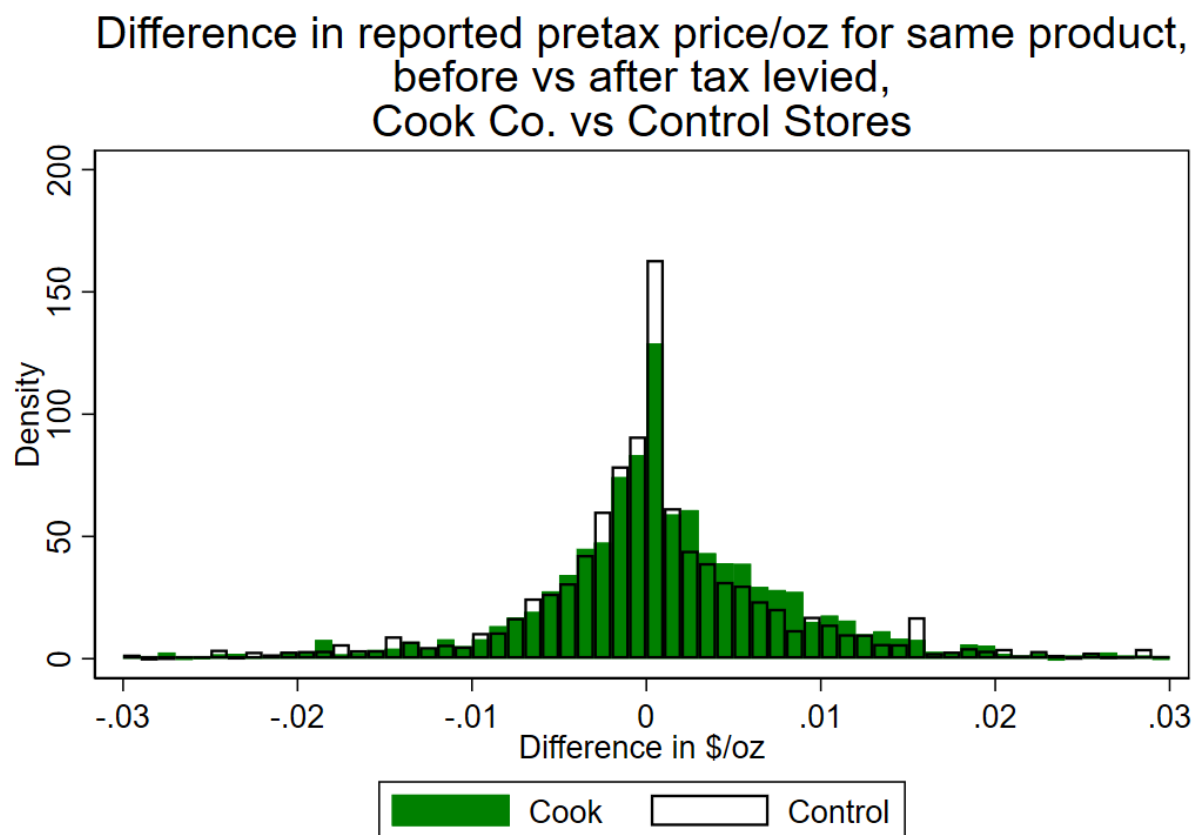
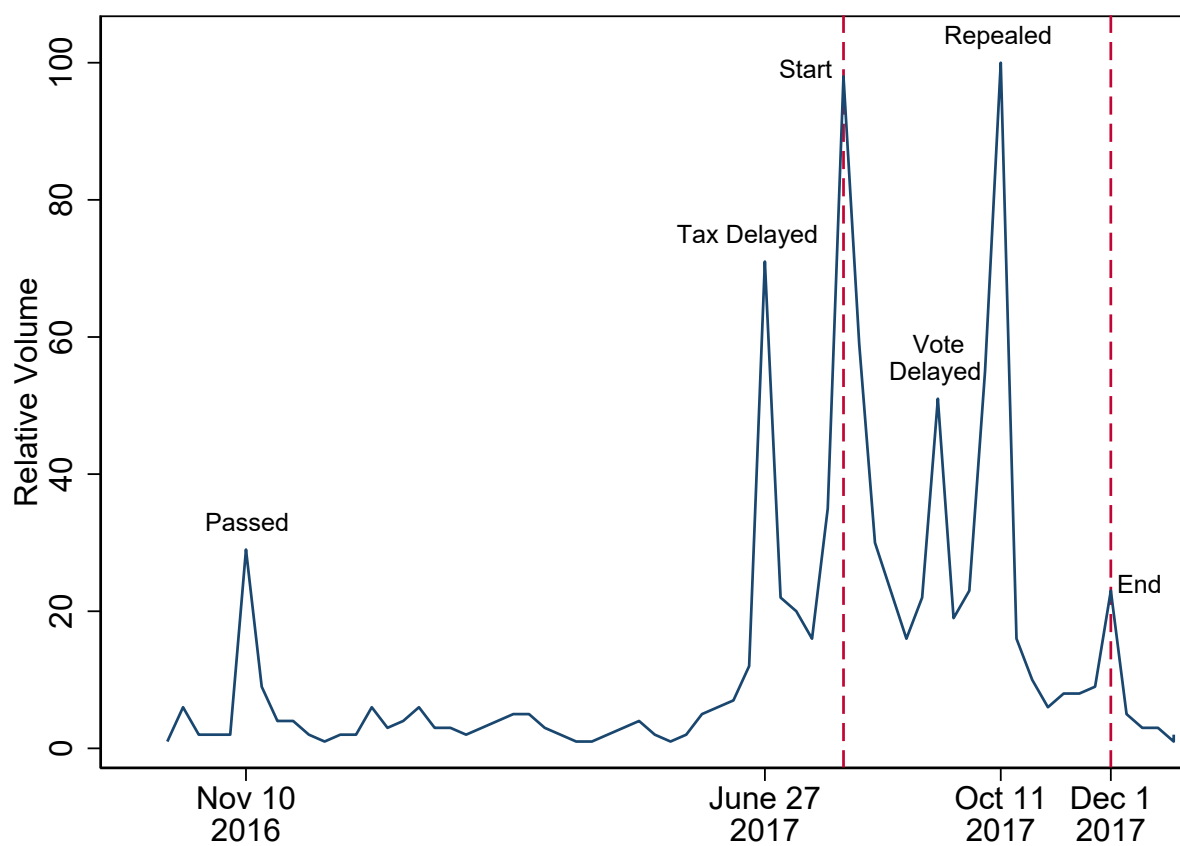


Figure A9: Distribution of differences in price per ounce during pretax versus taxed periods for carbonated beverages

Figure A10: Relative weekly search volume for “soda tax”



This plot displays Google search volume in Illinois for the keywords “soda tax”. Each point is the volume in Illinois relative to the total search volume for that week in Illinois scaled so that the highest week’s search volume is 100.